ART OF DYEING AND STAINING MARBLE, ARTIFICIAL STONE, BONE, WOOD, &c.

THE ART OF
DYEING AND STAINING
MARBLE, ARTIFICIAL STONE,
BONE, HORN, IVORY AND WOOD

AND OF

IMITATING ALL SORTS OF WOOD

A PRACTICAL HANDBOOK FOR THE USE OF JOINERS, TURNERS, MANUFACTURERS OF FANCY GOODS, STICK AND UMBRELLA MAKERS, COMB MAKERS, ETC.

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PREFACE.

In recent times the dyeing and staining of wood, bone, horn and ivory, like so many other crafts, has been completely revolutionised, and has experienced a complete series of improvements. The introduction of the coal-tar colours has put at the disposal of the industry a number of dyes and stains which are now used in enormous quantities. Many dyers and stainers long remained ignorant of the very existence of these artificial dye stuffs.

In spite of the compulsory limitation of space, this manual gives an exhaustive account of the modern practice of dyeing and staining wood, bone, ivory and marble. All new processes have been tested, and have been inserted only when they have been found to be of practical utility. In this way much space has been saved for really important matter.

I have adhered strictly to my intention of giving only reliable recipes, and that in such a form that any practical worker can make use of them without further trouble. I hope, therefore, that this little work will be found of real service to the industry.

THE AUTHOR.

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INTRODUCTION.

The dyeing or staining of wood, ivory, bone and marble essentially consists in giving them a different colour from their natural one. It goes without saying that the process adopted must depend on the nature of the material. As a general rule, the deeper the stain penetrates the more durable the resulting colour will be. Most of the dyes used are gradually bleached by exposure to light and air, so that it becomes necessary to protect them from air, light and damp by a coating of varnish.

While in the textile colouring industries we draw a distinction between dyeing (Färben) and mordanting (Beizen), and always regard the latter operation as preliminary to the former and as making the material fit to take up the dye, we do not recognise any such distinction in the branch of dyeing dealt with in this book. I should like to say that the words "Färben" and "Beizen" are here looked upon as synonymous, to prevent all risk of misapprehension.

The directions given for the production of the different colours on the materials treated of are fully given in

the body of the book. It has, however, been necessary to condense everything as much as possible. It need only be mentioned here that the operator will not get good results, even with the use of the best recipe, unless he understands the substances he is working with and the way in which they behave one to another.

1. MORDANTS AND STAINS.

I.

ACIDS.

Sulphuric Acid.

Of all the acids which are used for our purposes sulphuric acid certainly takes the chief place. It is partly used with other stains to give them particular shades or for the solution of indigo.

As a rule, two sorts of this acid are known, the difference being in the method of manufacture.

The so-called English sulphuric acid is made by burning sulphur or iron pyrites in ovens with a good draught. The sulphurous acid produced passes, by a somewhat high chimney, into the so-called lead chambers. These are rectangular rooms of lead, supported by wooden framing, and arranged in series so that the gas passes through them in turn. An uninterrupted supply of air, which is necessary for the success of the operations, is introduced through a pipe leading from the last chamber to the grate of the ovens. In the first chamber the mechanical impurities of the sulphurous acid settle to the floor, and the purified gas passes into the second chamber, which contains vessels filled with nitric acid. This is reduced by the sulphurous acid, forming oxides of nitrogen, and then nitrous acid, which becomes intimately mixed with the sulphurous acid. The mixture passes into the third

chamber, into which steam is blown. This, mixing with the two gases, converts the sulphurous into sulphuric acid, by means of oxygen from the nitrous acid. The dilute sulphuric acid falls in drops on to the floor of the chamber. A fourth smaller chamber is requisite to complete this precipitation of the sulphuric acid, and into it also steam is blown. Oxides of nitrogen escape thence into the outer air. The sulphuric acid thus obtained is, however, very much diluted, and must be concentrated first in lead and then in platinum vessels. English sulphuric acid generally has a density of 66 deg. B.

The preparation of the so-called Nordhausen sulphuric acid is quite different. Here sulphate of iron, consisting, as is well known, of ferrous oxide, sulphuric acid and water, is first calcined in special ovens to get rid of the larger part of its 40 per cent. of water, and then heated more strongly in ranges of long-necked fireclay retorts over an open fire. As soon as white fumes (anhydrous sulphuric acid) issue from the necks of the retorts, the condensers are luted on, and the fire is raised till the retorts are red-hot, and they are kept so till the condensers, which heat up at first, begin to get cool again. This is a sign that all the sulphuric acid has been distilled over, and that the process is therefore at an end. The yield is about 45 per cent. of sulphuric acid, which is at once stored in earthenware bottles. The residue in the retorts consists principally of sesquioxide of iron, a substance which, when ground and levigated, is known as rouge or colcothar. This process used to be confined almost exclusively to Nordhausen whence the acid was sent in all directions.

These two sorts, quite differently manufactured, of sulphuric acid, although agreeing in their geueral properties, yet differ in many respects. Nordhausen acid emits thick white fumes when a vessel of it is opened, and English sul-

phuric acid does not. The reason is to be found in the peculiar constitution of the Nordhausen acid. While the English acid consists of equal parts of anhydrous acid and water, so that it is a hydrate of the former, the acid from Saxony consists of a compound of this hydrate with the anhydrous acid. It is the escape of the anhydrous acid that causes the fumes above spoken of, when it combines with the water vapour of the atmosphere. It can thus be readily seen how injurious it is to the Nordhausen acid to leave the vessel containing it open. Indigo dissolves much better in the Nordhausen than in the English acid. Nordhausen sulphuric acid is thick like oil, so that it deserves the name of oil of vitriol better than the English acid, which is somewhat thinner. Both acids are remarkable for their extraordinary affinity for water. They not only absorb enough water vapour from the air to become considerably diluted, but when added to water combine with it with much evolution of heat. Two practical warnings can be deduced from these circumstances. One is to keep bottles of sulphuric acid carefully stoppered; the other is never to pour water on to the acid. If this is done, so much steam will be generated that the acid will be thrown violently about. It is essential always to pour the acid into water, and that slowly and with constant stirring, especially if the water is hot.

Nordhausen oil of vitriol freezes at 18 deg. C., the English acid at 34 deg. C. Both kinds of acid can be bought quite pure enough for our purposes. It is only necessary to see that the density is as high as it professes to be. This can always be easily ascertained by means of a hydrometer.

Hydrochloric Acid.

This substance is artificially prepared by distilling common salt with sulphuric acid. To get anhydrous hydrochloric acid the vitriol must be used concentrated, but it is used diluted when it is intended to make dilute hydrochloric acid. In a state of purity hydrochloric acid is colourless. It may be made yellow by dirt having fallen into it, or by the presence of a trace of free chlorine. The white fumes which it forms in the air are formed by the hydrochloric acid gas which escapes from it condensing with atmospheric water vapour. Concentrated hydrochloric acid has a destructive action both on vegetable and on animal substances. Its commonest impurities are sulphuric acid and sulphate of soda, which have been mechanically carried over by a too rapid distillation. Chloride of iron, too, may be carried over if the salt used contains iron. Free chlorine as an impurity in hydrochloric acid means that the oil of vitriol used in its manufacture contained nitric acid, which sets free the chlorine from some of the hydrochloric acid.

Aqua-regia is made by mixing hydrochloric acid with twice its weight of nitric acid. It contains free chlorine, by means of which it exerts most of its effects.

Hydrochloric acid is often used for bleaching various materials, and is much employed in producing brilliant shades in wood-dyeing.

Nitric Acid.

For our purposes, the use of nitric acid is somewhat restricted. It is used mixed with other stains, or alone for the production of yellows.

It is a colourless liquid, with a characteristic acid smell and taste. When concentrated it emits into the air slight

white fumes, which are caused by the vapour of the acid combining with moisture from the air. It absorbs moisture from the atmosphere. The commercial reddish-brown aqua-fortis is the strongest nitric acid mixed with nitrous acid. From what has been said about nitric acid, it follows that it too must be kept in carefully closed vessels.

Sulphurous Acid.

This acid is of no interest to us, except as a bleaching agent.

Sulphurous acid is formed by direct combination when sulphur is burnt in air or in pure oxygen, and also by roasting many metallic sulphides, such as pyrites. It can be obtained chemically pure together with sulphate of copper by heating copper with concentrated sulphuric acid. Another way is to mix 24 lb. of anhydrous ferrous sulphate with 10 lb. of sulphur, and to heat the mixture in a retort provided with a wide delivery tube. The residue in the retort is sulphide of iron, which can be used for making sulphuretted hydrogen. Sulphurous acid is a colourless gas of sp. gr. 2.27, and smells like burning sulphur. Its inhalation causes coughing and a feeling of suffocation. It neither burns nor supports combustion, and burning substances are at once extinguished by it. At from 15 to 20 deg. C. and under a pressure of three atmospheres it liquefies to a mobile fluid of sp. gr. 1.49, which produces great cold on evaporating. It is fairly soluble in water, which absorbs eighty times its own volume of the gas at 0 deg. C., and fifty times at 10 deg. C. The solution is colourless and acid, with a suffocating smell like that of the gas. It has an unpleasant taste, and is rather unstable. The gas bleaches many dyes in the presence of water, without, however, actually destroying the colouring matter as chlorine does.

Oxalic Acid.

This acid occurs in commerce in finely formed four-sided white plates, and is used a good deal for our purposes. It is used for grading many colours, and materially assists sulphurous acid in bleaching.

Other acids, such as tartaric and citric, are not used in our business. The two just mentioned are dearer than oxalic acid, and give no better results than that acid, which is cheap and effective.

II.

ALKALIES.

Caustic Soda.

Caustic soda, or sodium hydrate, is put on the market in drums or in solutions of various strengths. It is prepared by the action of lime on a solution of carbonate of soda, when the carbonic acid is transferred to the lime. The caustic soda lye is drawn off, evaporated to the proper concentration, and then filled into iron drums in which it sets to a solid mass. The following table of caustic soda lyes (after Lunge) will be found useful:—

Specific Gravity.	Degrees Baumé.	Percentage of NaHO by volume.	Grammes NaHO per litre.
1.007	1	.61	6
1.014	2	1.2	12
1.022	3	2	21
1.029	4	2.71	28
1.036	5	3.25	35
1.045	6	4	42
1.052	7	4.64	49
1.06	8	5.29	56
1.067	9	5.87	63
1.075	10	6.55	70
1.083	11	7.31	79
1.091	12	8	87
1.1	13	8.68	95
1.108	14	9.42	104
1.116	15	10.06	112

Specific Gravity.	Degrees Baumé.	Percentage of NaHO by volume.	Grammes NaHO per litre.
1.125	16	10.97	123
1.134	17	11.84	134
1.142	18	12.64	144
1.152	19	13.55	156
1.162	20	14.37	167
1.171	21	15.13	177
1.18	22	15.91	188
1.19	23	16.77	200
1.2	24	17.67	212
1.21	25	18.58	225
1.22	26	19.58	239
1.231	27	20.59	253
1.241	21	21.42	266
1.252	29	22.64	283
1.263	30	23.67	299
1.274	31	24.81	316
1.285	32	25.8	332
1.297	33	26.83	348
1.308	34	27.8	364
1.32	35	28.83	381
1.332	36	29.93	399
1.345	37	31.22	420
1.357	38	32.47	441
1.37	39	33.69	462
1.383	40	34.96	483
1.397	41	36.25	506
1.41	42	37.47	528
1.424	43	38.8	553
1.438	44	39.99	575
1.453	45	41.41	602
1.468	46	42.83	629
1.483	47	44.38	658
1.498	48	46.15	691
1.514	49	47.6	721
1.53	50	49.02	750

The solution of caustic soda when packed in a drum is always attended with difficulty and risk, unless an apparatus is at hand for dissolving the caustic soda in the drum by means of a current of steam. This is done by placing the drum over a pan intended to catch the lye flowing from it. A suitably placed pipe leads the steam from below into an opening made at the proper spot, and the melting process begins of itself.

Carbonate of Soda.

Carbonate of soda, or sodium carbonate, formerly made by burning certain sea-weeds, is now an artificial product only. Its manufacture may be divided into the old, or Leblanc process (now almost obsolete), and the Solvay process, which is now practised in all civilised countries. It consists in saturating with carbonic acid a brine previously treated with ammonia gas, whereupon carbonate of soda is precipitated. The precipitate is ignited, and the resulting mono-carbonate is sold as calcined soda.

Anhydrous calcined soda contains 58.58 per cent. of soda, and 41.42 per cent. of carbonic acid; while the crystallised salt contains 21.81 per cent. of soda, 15.43 per cent. of carbonic acid, and 62.76 per cent. of water.

The following is a table of carbonate of soda solutions after Lunge:—

Specific Gravity.	Degrees Baumé.	Weight per Cent. of Na_2CO_3.	Grammes Na_2CO_3 per litre.
1.007	1	.67	6.8
1.004	2	1.33	13.5
1.022	3	2.09	21.4
1.029	4	2.76	28.4
1.036	5	3.43	35.5
1.045	6	4.29	44.8
1.052	7	4.94	52
1.06	8	5.71	60.5
1.067	9	6.37	68
1.075	10	7.12	76.5
1.083	11	7.88	85.3
1.091	12	8.62	94
1.1	13	9.43	103.7
1.108	14	10.19	112.9
1.116	15	10.95	122.2
1.125	16	11.81	132.9
1.134	17	12.61	143
1.142	18	13.16	150.3
1.152	19	14.24	164.1

Borax.

Sodium borate or borax is a compound of soda and boric acid. It has only feebly alkaline properties, but has nevertheless much dissolving and purifying action. Unfortunately it is dear, so that its use is not universal.

Waterglass.

Waterglass or silicate of soda is obtained by fusing together 100 lb. of finely powdered quartz, 60 lb. of calcined Glauber's salt and from 15 to 20 lb. of coal. It comes on the market mostly in the form of a syrup, and contains about 65 per cent. of water and 27 per cent. of silica.

Ammonia.

Liquid ammonia is a solution of ammonia gas in water, which can absorb half its own weight of the gas, thereby acquiring its characteristic smell, taste and properties. As the water increases largely in volume by absorbing the gas, the specific gravity of the solution is less than that of water. In fact, the specific gravity of solutions of ammonia is the best test of their value. All adulterations and impurities increase the specific gravity. Ammonia can be obtained in all sorts of different ways, for example from putrid urine, from nitrogenous animal offal such as horns, hoofs, hair, etc., but at present it is prepared solely from the so-called ammonia-liquor from gas-works.

The following table shows the percentage of ammonia in solutions of different specific gravities:—

Specific Gravity.	Percentage of NH_3	Specific Gravity.	Percentage of NH_3
.8844	36	.8877	34.4
.8848	35.8	.8881	34.2
.8852	35.6	.8885	34
.8856	35.4	.8889	33.8
.886	35.2	.8894	33.6
.8864	35	.8898	33.4
.8868	34.8	.8903	33.2
.8872	34.6	.8907	33
.8911	32.8	.9021	28.2
.8916	32.6	.9026	28
.892	32.4	.9031	27.8
.8925	32.2	.9036	27.6
.8929	32	.9041	27.4
.8934	31.8	.9047	27.2
.8938	31.6	.9052	27
.8943	31.4	.9057	26.8
.8948	31.2	.9063	26.6
.8953	31	.9068	26.4
.8957	30.8	.9073	26.2
.8962	30.6	.9078	26
.8967	30.4	.9083	25.8
.8971	30.2	.9089	25.6
.8976	30	.9094	25.4
.8981	29.8	.91	25.2
.8986	29.6	.9106	25
.8991	29.4	.9111	24.8
.8996	29.2	.9116	24.6
.9001	29	.9122	24.4
.9006	28.8	.9126	24.2
.9011	28.6	.9133	24
.9016	28.4	.9139	23.8
.9145	23.6	.9245	20.2
.915	23.4	.9251	20
.9156	23.2	.9257	19.8
.9162	23	.9264	19.6
.9168	22.8	.9271	19.4
.9174	22.6	.9277	19.2
.918	22.4	.9283	19
.9185	22.2	.9289	18.8
.9191	22	.9296	18.6
.9197	21.8	.9302	18.4
.9203	21.6	.9308	18.2
.9209	21.4	.9314	18
.9215	21.2	.9321	17.8
.9221	21	.9327	17.6
.9227	20.8	.9333	17.4
.9233	20.6	.934	17.2
.9239	20.4	.9347	17

III.

METALLIC SALTS.

Iron Salts.

The few iron salts used in our dyeing must be briefly described. They are: ferrous sulphate, ferric sulphate, nitrate of iron, ferric chloride and pyrolignite of iron.

Green vitriol or ferrous sulphate is prepared artificially by exposing heaps of roasted iron pyrites to the air for a long time. Water is poured over the mass at intervals, and the liquid which runs off and contains the vitriol in solution is collected. The copper it contains is removed by means of scrap-iron, and the green vitriol is then crystallised.

Pure ferrous sulphate has a sea-green colour, and forms rhombic prisms. Its taste is astringent and ink-like. It dissolves in water, forming at first a green solution, which gradually becomes reddish-yellow, with precipitation of an insoluble basic salt of the same colour. Gently heated, green vitriol melts in its own water of crystallisation, and on drying out becomes a white powder. At higher temperatures it is decomposed, sulphuric acid coming off and sesquioxide of iron remaining behind. In warm, dry air the crystals crumble to a white powder by the loss of part of their water of crystallisation. At the same time part of their ferrous oxide oxidises to sesquioxide. In consequence of this the salt assumes a grass-green colour, and becomes covered with brown specks.

There are different kinds of this vitriol on the market. One is sea-green, and is pure ferrous sulphate. Another is grass-green, a mixture of ferrous and ferric sulphates. Another is black vitriol, an impure ferrous sulphate containing free sulphuric acid, so that it is always damp, and

reddens litmus strongly. It can be purified by recrystallisation, by which means a bluish-green variety is obtained. Iron-vitriol crystals aggregate together into bunches or else into lamellar masses. The first sort can be got by placing sticks or ropes in the crystallising pan, when the crystals form round them. The others are deposits on the sides and bottoms of the crystallising pan. These crystalline masses are often met with broken to pieces. Good green vitriol should have neither white nor brown specks, but should consist of pure crystals with a fine glossy lustre.

There is also on the market a variety called Salzburg vitriol. This must be looked after, as it is very different from ferrous sulphate, for besides that substance it contains the sulphates of copper and zinc.

Ferric sulphate is, as its name denotes, a compound of sesquioxide of iron and sulphuric acid. It occurs combined with water in various proportions. Only the pure salt is of interest for us, as the basic compounds are all insoluble in water.

Dry ferric sulphate is a resinous light green-yellow powder, which is without smell, but, like its solution, has a very harsh taste. It is deliquescent in the air, and should dissolve in water and alcohol in all proportions. When ignited it gradually loses all its sulphuric acid, and leaves a colcothar of a beautiful carmine red colour. Ferric sulphate should be tested for nitric acid, ferrous salts, copper and zinc.

So-called red-burnt copperas, which consists mostly of sesquioxide of iron, is made by heating ferrous sulphate nearly to redness and then mixing it with one quarter of its weight of common salt, and raising the mixture to a full red heat. For our purposes this compound of iron is used, but only occasionally, for the black dyeing of certain kinds of wood.

Nitrate of iron occurs in commerce in two forms, ferrous nitrate and ferric nitrate. In the latter the iron is fully oxidised, and the salt gives blacks with tannin or gallic acid. At the same time, however, it has a very destructive effect upon woody fibre on account of the large proportion of acid it contains, so that it is not of much practical use. One usually prepares one's own nitrate of iron by mixing nitric acid with half its weight of water, and then throwing in iron filings and scraps of wire every four hours till the acid will dissolve no more. The whole process lasts about a fortnight, and the weight of iron used is about one-twelfth of that of the dilute acid. Finally the solution loses the smell of nitric acid, and is brown. It is filtered through linen, and kept in the dark in well-stoppered bottles.

Tartrate of iron is a very soluble jelly-like uncrystallisable reddish-brown compound. It is used with alizarine for certain brown stains on wood. It is most easily made by re-acting on chloride of iron with cream of tartar.

The so-called nitrate of iron of commerce, which, as is well known, is only oxidised sulphate, is of no use to us, as it contains far too much sulphuric acid and is very acid and sharp. Used on wood, it would do nothing but harm. Real nitrate of iron is much used for dyeing marble yellow.

For dyeing marble, artificial stone, horn, etc., chloride of iron is largely used; that is, the ferric chloride, for the other chloride—ferrous chloride—is comparatively seldom employed. This is, however, only because we are used to the per-salt. If we accustomed ourselves to the other, we should very likely find that it gave the better results of the two.

Ferric chloride is prepared by adding nitric acid to ferrous chloride till it has assumed a dark brown colour, and then driving off the excess of acid by gentle heat.

The solution is dark brown, and will not crystallise. On evaporation it leaves a dry orange-coloured mass which is very hygroscopic and consists of 33 per cent. iron and 67 per cent. chlorine. Ferrous chloride is best made by saturating a mixture of hydrochloric acid of 22 deg. B. and half its weight of water with clean iron filings. Hydrogen is evolved, and a pale green solution remains, which can be used as liquid protochloride of iron. When it is crystallised it gives a pale green salt, which is very soluble in water, and in air decomposes into ferric chloride and oxide of iron.

One of the iron preparations which we most commonly use is the pyrolignite. It has the advantage over all the other iron salts that it gives up its oxide of iron more easily to the material to be stained or to the dye, and also that it is much less acid than the other salts of iron, so that it dyes our materials much better and does not injure their texture. Any free acetic acid, too, which may be present soon evaporates as the goods dry after dyeing, and does not remain to act injuriously on the material.

Ferrous acetate or blackstain possesses a characteristic smell and a greenish colour. The iron in it remains in the ferrous state, as long as an excess of iron is kept in the solution. A greenish-yellow colour indicates that the sub-oxide has begun to pass into the state of sesquioxide. It is prepared by dissolving scrap-iron in vinegar, excluding the air as much as possible, for contact with oxygen easily converts the compound into basic ferric acetate.

Ferric acetate solution is not much used. It has a dark brownish-red colour, and tastes like ink. Heat decomposes it, acetic acid being evolved and a basic salt separating out in the form of a jelly and finally becoming hydrated ferric oxide.

Copper Salts.

Of these only four have any importance for us, *viz.*, ordinary blue vitriol, the chloride, verdigris, and cuprate of ammonia.

Blue vitriol or sulphate of copper, otherwise bluestone, is used in large quantities by all colouring trades whenever it is a question of getting dark or black colours with logwood.

Crystallised sulphate of copper is only occasionally found in nature, weathered out of copper pyrites, or in the effluent of copper-works which has dissolved sulphate of copper resulting from the oxidation of coarse metal. The salt can be obtained from this solution by merely evaporating off the water, but it is usually appropriated for the manufacture of metallic copper. The salt can also be prepared by oxidising the copper and dissolving the oxide in dilute sulphuric acid. It is, however, most usually got by lixiviating copper ores which have been partially converted into sulphate by roasting.

Simple copper sulphate contains 31.79 per cent. of copper oxide, 32.14 per cent. of sulphuric acid and 16.07 per cent. of water. It crystallises in rhomboid blue flat crystals, which in warm air fall to powder by the loss of their water of crystallisation. After a time, however, they take back moisture from the air and become blue. In damp air the crystals do not crumble, as naturally they do not lose their water to such air. At high temperatures the salt fuses and loses its colour, and finally loses its sulphuric acid, and is converted into copper oxide. Sulphate of copper is soluble in five times its weight of cold, in twice its weight of hot, water, but is insoluble in alcohol. It is very often contaminated with iron, and sometimes contains free sulphuric acid, especially when prepared

from solutions of copper-alloyed silver coins. The former impurity can be recognised by the presence in the precipitate, got by adding ammonia to the dissolved salt, of brown ferric hydrate as well as the blue hydrate of copper. The other shows itself by the crystals keeping damp, owing to the absorption of moisture from the air by the sulphuric acid, and also by the solution of such a blue vitriol reddening litmus paper.

The mixed vitriols usually occur in the form of bunches, and have a bluish-green colour; the blue being less pronounced as the amount present gets less.

Chloride of copper comes on the market partly in solution (usually of 40 deg. B.) and partly in prismatic emerald-green crystals. It is nothing like so much used in our craft as copper sulphate. It contains distinctly more free acid (hydrochloric acid) than the sulphate, so that it acts very sharply on wood and horn. It is made by dissolving copper oxide in hydrochloric acid. The crystals rapidly absorb water except in well-stoppered bottles.

Verdigris is made on a large scale in many places in Germany, Holland and England, but especially at Montpellier in France. Copper plates and the freshly pressed marc of the grape are interstratified in piles and left for from four to six weeks. The marc (residue from the wine press) soon ferments, becomes warm, and evolves acetic acid, which combines with the copper which has been oxidised by the air. When the mass cools it is a sign that the fermentation has ceased. Then the plates are supplied with fresh marc. Another plan is to expose the copper plates to the fumes of arsenic or pyroligneous acid. When in any case they have become covered with a sufficiently thick crust of acetate of copper they are placed in earthenware vessels and wetted with vinegar. This makes the crust blister and facilitates its removal from the metal. The salt, which is contaminated with fragments of copper and bits of

the marc, is packed in sheepskins, kneaded with a little wine, and then put on the market.

A good specimen of verdigris must not turn damp in the air, and must contain no black or white specks. It should be bluish-green, have a slight smell of vinegar, and a nauseous metallic taste. Proust considers that verdigris is a compound of neutral copper acetate with hydrated copper oxide and the concomitant water of crystallisation. If verdigris is treated with cold water it breaks up into three different salts—neutral acetate of copper, a soluble basic salt, and an insoluble basic salt. But if warm water is used in small quantities the mass becomes dark blue, and contains a large preponderance of the insoluble basic salt, which, on cooling, settles out as an irregular blue mass without any trace of crystallisation.

If verdigris is boiled in plenty of water it turns brown, and the more water is used the less heat is necessary to effect the change, which may take place even at 40 deg. C. A brown hyperbasic salt precipitates, and the very dilute solution contains free acetic acid and the neutral acetate of copper.

Hence verdigris is only partly soluble in water, but in acetic acid it dissolves with the exception of traces of impurities. From these it can be purified by powdering or rubbing through a sieve. Intentional adulteration with chalk, gypsum, etc., can be detected by dissolving the salt in dilute sulphuric acid. With either of the two impurities named present, sulphate of calcium will remain undissolved. Verdigris dissolved in wax is largely used for dyeing marble.

Ammonium cuprate is only used for special purposes described below. It is made by adding caustic ammonia to sulphate of copper till the precipitate, which is first grey and then blue, has dissolved again. When evaporated,

the solution leaves crystals which give off ammonia in the air, and crumble to a green powder.

Aluminium Salts.

For us the most important of these are alum, aluminate of soda, and sulphate and acetate of aluminium.

Alum has, for our purposes, a distinct advantage over aluminium acetate, because it is in a more convenient state, and can be obtained anywhere in sufficient purity. Alum occurs in various crystalline forms in nature, in stalactitic rough masses efflorescing into small acicular crystals, for example in the alum-shales. It also occurs in a fibrous state, as in the Island of Milo in the Grecian Archipelago, but at present the alum used in the various branches of industry is artificially prepared. One of the chief raw materials used is alum-shale. This, however, contains only two of the necessary ingredients for the formation of alum, *viz.*, alumina and sulphur, and has to be roasted, weathered, and treated with alkali after the roasting. The alkali makes the mass brittle and crumbly, and facilitates its oxidation by the air. The shale is then lixiviated in wooden vessels to extract the sulphate of alumina from it. The crude lye is allowed to settle, and then put through a filter press. The clear lye is then evaporated to a certain point in pans, and then mixed with an alkaline sulphate. According to the nature of the latter we get potash-, soda-, or ammonia-alum. When the second salt is added the alum falls to the bottom of the pan in the form of a meal, so that the addition of the second salt is known as mealing. The supernatant liquid is run off, and the alum is washed with cold water, and dissolved in just so much boiling water that the alum will crystallise out on cooling. The crystallisation is furthered by providing the inside of the crystallising vessels with numerous projecting rods over

which the crystals form. The vessels themselves are deep, and either cylindrical or conical. The masses of tabular crystals are broken up and at once packed into casks. A similar raw material to alum-shale is alum-earth, for it contains no ingredients for alum-making beyond alumina and sulphur, and for the same reason it is treated exactly as above described in the case of alum-shale.

As just mentioned, alum is, in chemical composition, a compound of neutral sulphate of alumina with neutral sulphate of potash, or soda, or ammonia. It therefore belongs to the class of double salts, as it contains two bases and an acid common to both. Its crystals are octohedral, colourless and transparent. When, however, the salt is basic, *i.e.*, contains an extra quantity of alumina, the crystals are cubical. All the alums are soluble in water, and more in hot than in cold water. Their taste is sweet but astringent. Gently heated, they melt in their own water of crystallisation, and finally form a white porous mass, which is sold under the name of burnt alum (*alumen ustum*). The facility with which any one of the three alums can be made is due to the power of sulphate of alumina to form a double salt with the other sulphate, and then to crystallise out with it in a regular determinate form.

The alkaline salts, on the other hand, take one another's place to make the different alums, and must be regarded in that capacity. The alumina can also be replaced by other bases, such as the sesquioxides of chromium and iron, so that we have also chrome-alum and iron-alum. Neither of these alums is used in our art, and we need take no further notice of them.

Commercial alum not infrequently contains traces of iron, which is a great drawback, especially to its use in red-dyeing. The alum can be very simply tested with a few drops of a saturated solution of ferricyanide of

potassium. If this produces a blue colour at once or after a few hours, the alum is useless for the finer kinds of dyeing. But if, on standing throughout the night, it produces no blue colour, or only a very faint one, the alum may be regarded as being free from iron. In the present state of alum-manufacture it is very difficult to get the salt absolutely free from iron.

Sulphate of alumina comes upon the market in the form of white amorphous plates. It readily dissolves in water, and contains alumina free from such adjuncts as lime, soda, or ammonia, and is therefore, when not too acid, naturally more suitable and economical for use than alum.

Sulphate of alumina is now prepared on a commercial scale from cryolite. In a furnace, cryolite is heated with six times its weight of limestone, and while carbonic acid escapes calcium fluoride and sodium aluminate remain. The mass is lixiviated with water, which dissolves the aluminate from the insoluble fluoride of lime. The solution is precipitated by means of the carbonic acid, which is collected for the purpose, and forms carbonate of soda in solution and hydrate of alumina as a precipitate. The latter is dissolved in sulphuric acid, and the sulphate of alumina remains when the solution is evaporated to dryness.

Contamination of sulphate of alumina with ferric sulphate can be detected by adding ferrocyanide of potassium to the solution of the sulphate. In the presence of iron a blue precipitate is formed, or if the foreign metal is only present in traces, merely a blue colour. Potassium sulphocyanide added to solution of sulphate of alum gives a red colour if iron is present even although its amount may be small.

Acetate of alumina contains a larger percentage of alumina than other alumina salts. It very readily gives up the acetic acid and forms an insoluble compound richer

in alumina. Another advantage of acetate of alumina is that it will not crystallise and the affinity which it possesses for dyes, with which it forms insoluble compounds.

For the preparation of acetate of alumina, until only a few years ago, alum was always used in combination with various acetates such as sugar of lead and acetate of lime or baryta, and in many cases acetate of soda. To-day, sulphate of alumina is used as a raw material. This is first converted into hydrate of alumina by precipitation with carbonate of soda. The hydrate is thoroughly washed with hot water till the washings are without action on litmus paper, and then dissolved in acetic acid. According to the proportion of the hydrate of alumina to the acid and to the dilution of the latter, we get solutions of acetate of alumina of various strengths, which behave differently on heating.

Instead of pure acetic acid pyroligneous acid has been used of late, which lessens the cost of manufacture of the acetate of alumina and makes it give fuller shades with many dyes.

For certain purposes other chemicals are mixed with acetate of alumina, such as arsenious acid, zinc chloride, common salt, sal-ammoniac and many others. Those which absorb moisture from the air, as zinc chloride does, are those mostly used.

The value of acetate of alumina is not judged of by its gravity, because the other salts present also affect the hydrometer. It stands to reason that that value depends on the proportion of alumina present in solution as basic sulphate or as acetate.

Aluminate of soda is prepared by heating cryolite with limestone in a furnace. It is soluble in water, and very easy to use.

In the preparation of aluminate of soda, alum is dissolved in water, and gradually mixed with caustic soda

until the latter has completely redissolved the alumina which it at first precipitates.

We are unfortunately prevented from anything like extensive use of aluminate of soda by the hyperalkalinity it so often manifests.

Chrome Salts.

The only chromates for use are those of potash and soda. Among these we distinguish the neutral chromates of soda and potash, also called the yellow chromates, and the acid or double chromate of these bases, also called the red chromates.

The yellow chromates form hard lemon-yellow rhombic crystals, which, in the case of the potash salt, are permanent in the air. The bichromates crystallise in very beautiful triolinic four-sided plates which are permanent in the air. They melt when heated, have a very sharp, unpleasant taste, and are poisonous. The potash salt dissolves in from nine to ten times its weight of cold, and in from four to five times its weight of hot water. The soda salt is rather more soluble.

Neutral chromate of potash or soda is prepared from chrome iron-stone (sesquioxide of chrome and protoxide of iron). This is ignited with twice its weight of saltpetre, and the chromate of soda or potash formed is extracted from the mass with water. The solution is neutralised with nitric acid, filtered from the precipitated alumina and silica, and evaporated to crystallisation.

Bichromate of soda or potash is prepared by decomposing a solution of the neutral salt with nitric acid, and then evaporating to crystallisation. Acetic acid can also be used instead of nitric. The yellow chromate gives up a part of its alkali to the acetic acid, and the red salt settles to the bottom in the form of an orange-red

powder. The liquid is decanted, the powder is washed thoroughly, dissolved in hot water, and finally evaporated till it crystallises.

These chromium salts are most used, in combination with logwood, for black dyeing on all kinds of material, but they also serve for the production of the well-known chrome yellow and chrome orange. These are prepared by making chromate of potash or soda re-act in solution with acetate of lead. The double decomposition gives rise to precipitation of the insoluble pigment.

Chromic acid itself is used for black dyeing like the bichromates, especially for wood, bone and ivory. At the same time the use of chromic acid requires great care, as it is corrosive, and therefore easily injures the material to be dyed, more especially if it be wood. It also quickly destroys the brushes and makes them useless. On account of the powerful oxidising properties of chromic acid it must not be kept in wooden vessels, except those which are protected by an inside coat of a composition of resin fused with twice its weight of wax. This not only preserves the wood, but saves waste of chromic acid, which, when it oxidises the wood, becomes itself changed to brown chromium chromate. The same change is produced in chromic acid by water which contains much organic matter, as river and brook water often does.

The property of chromic acid to part with oxygen readily is also made use of for bleaching purposes. If, for example, cotton dyed with indigo is soaked in a solution of bichromate of potash, dried, and then printed with a dextrine thickening containing oxalic, tartaric, and a little nitric acid, those acids set free the chromic acid of the bichromate in the printed places, which become white by the destruction of the indigo. The same thing happens if chromic acid itself is printed on with the thickening, but the operation then becomes difficult on account of the

trouble of finding a thickening that can resist chromic acid.

To make chromic acid for ourselves we dissolve 6 oz. of bichromate of soda in 30 oz. of water, and then add 64 oz. of sulphuric acid free from lead, and of 60 deg. B. When the liquid cools, the chromic acid will crystallise out in dark red crystals, which, however, still contain some sulphuric acid. This can be partly removed by pressing the crystals between porous stones.

Tin-salt.

In our branch of dyeing the use of tin-salt for dyeing wood, ivory and bone has considerably decreased, and it is now hardly ever used except as an assistant to cochineal in scarlet dyeing.

Tin-salt is prepared by dissolving tin in warm concentrated hydrochloric acid, and then evaporating the solution till colourless prismatic or scaly crystals are formed. Instead of hydrochloric acid, aqua-regia is sometimes used, and sometimes a mixture of nitric acid and sal-ammoniac, or of nitric acid and common salt. Tin-salt (stannous chloride) thus prepared is hygroscopic and becomes damp in the air, turns yellowish, and deliquesces. At the same time it gradually absorbs oxygen, and becomes hydrated stannic oxide. On this account the salt must not only be kept dry but in well-stoppered bottles. It is decomposed by moderate heat in a still. At first only pure water comes over, then water containing tin and hydrochloric acid, and a basic salt remains, which, at higher temperatures is decomposed into anhydrous stannous chloride and stannous oxide. Tin-salt dissolves in a little water, but if water is added in excess turbidity results, as part of the chloride is decomposed, forming insoluble basic oxychloride, which remains suspended in the water. This precipitation

may be prevented by making the water first acid with hydrochloric acid, cream of tartar, tartaric acid, or oxalic acid.

Tin-salt has a disagreeable metallic taste and is very poisonous. It often contains small quantities of stannic chloride, and it is then advisable to put a plate of zinc into the solution, which will throw all the stannic tin down as stannic oxide.

Stannous nitrate is also used by us, but only in special cases, *e.g.*, for a special shade of violet, with logwood and redwood.

Stannous nitrate is prepared by dissolving hydrated stannous nitrate in dilute nitric acid. The salt is not crystallisable, as, when its solution is evaporated, stannic hydrate is precipitated in the form of a white powder. The solution is yellow.

Stannic nitrate is got by dissolving in cold nitric acid stannic oxide precipitated from stannic chloride. If the acid is heated the salt separates out in white crystals.

Lead Salt.

The only lead salt which concerns us is sugar of lead, neutral lead acetate. It crystallises in four-sided prisms or needles, has an astringent taste, and is poisonous. It dissolves freely in water, and contains 58.59 per cent. of lead oxide, 26.84 per cent. of acetic acid, and 14.21 per cent. of water. It is made by dissolving lead, litharge, or white-lead, in acetic or pyroligneous acid. Commercial sugar of lead usually contains basic or hyperbasic acetate, which prevents it from forming fine transparent crystals, so that this impurity is announced by the crystals being a turbid white. The pure salt crystallises in transparent prisms, does not redden litmus, turns violet-syrup green, and only effloresces slightly in dry, warm air, but completely if the air is at above 40 deg. C. or *in vacuo* over

sulphuric acid. By cautious fusion in the air it loses water and a little of its acid. On stronger heating it swells up, gives off acetic acid and combustible gas, leaving a mass which at still higher temperatures breaks up into carbonic acid, water, acetic acid, and free lead and carbon.

The prisms of sugar of lead when slowly formed are large, with two wide and two narrow sides, but also in the form of slender four-sided pyramids. The crystals possess great lustre, and their colour is white with sometimes a plug of yellow or red.

If the colour is bluish, it is a sign that too much contamination with metallic lead exists. This is also easily recognisable by the greater weight. A greenish colour shows the presence of copper; a yellowish one, that of iron, or that yellow acid was used in making the salt. The presence of lead and iron may be detected by adding sulphuric acid to a solution of the sugar of lead until all the lead is thrown down as sulphate, and then adding cyanide of potassium, which gives a brown with iron and a blue with copper. Sugar of lead dissolves in water, but always leaves a white residue of carbonate of lead, and which has been formed by the action of carbonic acid in the water or in the air. If a part of the sugar of lead will not dissolve in water it is either this carbonate of lead or hyperbasic acetate, or it may be heavy-spar, which is sometimes used as an adulterant of the salt. If it is hyperbasic acetate it will dissolve in strong acetic or nitric acid without effervescence. If it is carbonate of lead it will dissolve in those acids with effervescence, giving off carbonic acid. If it is heavy-spar, it does not dissolve. Sugar of lead is also adulterated with acetate of lime, more rarely with nitrate of lime, which betrays itself when the salt is treated with sulphuric acid, when nitrous fumes are evolved as well as those of acetic acid.

Manganese Salts.

Of the great list of these salts the only one of importance to us is permanganate of potash or soda. The potash salt is the one mostly used. In the textile trades it is used in the bleaching of silk, wool, etc., but in our craft it is only employed for brown dyeing, on wood especially. It must be used quickly, as its aqueous solution soon destroys the brushes. It must always be applied cold.

Permanganate of potash is made commercially by passing carbonic acid through a solution of crude potassium manganate till the colour becomes a purple-red. It forms larger or smaller rhombic prisms, which are black with a metallic lustre by reflected light and a deep violet-red by transmitted light. It dissolves in water to a deep purple-violet solution, which, when acidulated with sulphuric acid, has its colour discharged by sulphate of iron, sulphurous acid, hydrosulphite of sodium, or oxalic acid.

Silver and Gold Salts.

Of these we use only nitrate of silver and chloride of gold, and even these salts are only sparingly used on account of the expense incurred.

Nitrate of silver (*lapis infernalis*) usually occurs in commerce either in white fibrous masses, or fused into sticks. Its property of blackening organic matter under the influence of actinic rays is the reason for our using it. It must not be forgotten, however, that it is also very destructive to most organic substances. It dissolves in its own weight of cold water, and in half as much hot water.

Chloride of gold is a compound of gold and chlorine, and one of the dearest dyeing materials known. It is largely used only in porcelain painting. It is got by dissolving gold in aqua-regia, pouring off the solution from

the precipitated silver chloride,* and evaporating it to dryness by gentle heat on the water-bath. In this way a chloride is got absolutely free from uncombined acid. It is dissolved in distilled water for use in dyeing. Sometimes, especially if too much heat is employed in the evaporation, metallic gold remains undissolved, which must be filtered off and redissolved in aqua-regia. The separation of this metallic gold shows that some of the auric chloride was converted by overheating during the evaporation into aurous chloride, which is further decomposed with separation of the metal on the addition of water.

* The author presupposes that the gold used is a German eoin in which silver is the alloy.—*Tr.*

2. DYES AND PIGMENTS.

For better discrimination we divide the dyes and pigments under three heads:—

1. Natural Dyes.
2. Artificial Pigments.
3. Coal-tar Dyes.

IV.

NATURAL DYES.

Redwood, Pernambuco Wood, or Brazil Wood.

This is the wood of *Cesalpinia crista*, a tree indigenous to South America. The tree grows to a fair size. The heartwood is yellowish-red, the sapwood red. The timber is hard, heavier than water, and contains a yellowish-red dye, braziline, which Chevreul isolated in 1810.

Besides Pernambuco and Brazil wood, the following other sorts are on the market:—

Sapan or Japan wood and St. Marten's wood, also called Nicaragua wood, both relatively poor in colouring matter. For use in dye-works, the redwood should always be bought in the log, and rasped or ground by the purchaser, for ready-ground redwood is often adulterated with red sandal-wood, or with perished and mouldy redwood.

Redwood, like all other dye-woods, must be kept from sun and light as well as from damp, for all these agencies do much harm to the pigment.

Decoctions of redwoods have the common property of improving by keeping in the dark, and giving softer and purer shades.

Since the introduction of the aniline dyes the use of redwood has much decreased, chiefly because warmer tints can be got with the artificial dyes, and greater fastness to light. Redwood is still, however, largely used in combination with other pigments in the production of violet-reddish-brown and mode shades. But all colours so produced are inferior in fastness to light, and are rarely used except in wood-dyeing.

Red Sandalwood.

Pterocarpus santalinus is said to be the tree from which red sandalwood is obtained. Cuts in the bark of the same tree yield dragon's blood. The tree is indigenous to Ceylon and the neighbouring islands, and comes to us in heavy four-cornered pieces, blackish outside and blood-red inside, which have a very characteristic fibrous texture, or else in the form of raspings. The wood has a slight smell and a feebly astringent taste. The light red sort is preferred to the dark red. Four sorts of sandalwood are recognised by the trade—red, yellow, white and violet. We are concerned with the red only, as the others are never used for dyeing.

The testing of the wood for colouring power and for adulteration with logwood is best done by comparison of the colours got with others dyed with a sample known to be genuine and of excellent quality. In this way a very decisive opinion is easily formed. Adulteration with ochre is detected by incinerating the wood, previously dried at 100 deg. C. If there is a much greater percentage of ash than with genuine wood, ochre may be presumed to be present, and the conclusion may be confirmed by

dissolving the ash in nitric acid, and making the solution strongly alkaline with ammonia and smelling of that substance. If a flocculent brown precipitate (ferric hydrate) is formed, the presence of ochre in the sandalwood is certain.

Pelletier has shown that water hardly acts on this wood but that its colouring matter is easily extracted by alcohol, ether, acetic acid, or any alkali. The fatty and essential oils, however, except lavender or rosemary oil, extract no dye from it. This behaviour of sandalwood seems to be quite distinctive.

Madder.

Dyers' red or madder (*Rubia tinctorum*) is the root of a perennial Eastern plant, and used to be cultivated in the East and in several European countries. It dyes red saliva, water, spirit, ethereal oils, and even the bones of animals fed on it.

Many kinds of madder used to be on the market, but since the introduction of artificial alizarine one may say that the use of madder has almost entirely ceased, and hence its cultivation is a thing of the past. Exceptions may perhaps be met with in Holland.

As madder is thus of historical interest only we need say no more about it.

Orchil and Cudbear.

These are two dyes, or really only one, which have also been almost driven off the field by the aniline colours. and will soon be disused altogether as there are substitutes which are far better and cheaper.

Orchil and cudbear (the latter is dried orchil) are red substances shading off into violet, and are obtained from various kinds of lichen.

The raw lichens contain no pigment, which is produced by acting on them with alkalies in the presence of air. It is wine red, and turned violet by alkalies. Orchil is sold as a paste, cudbear as a powder. They are only partially soluble, and leave behind more or less residue according to the quality. Many dyers like orchil to dye bluish, while others again desire a reddish shade. It is, however, all the same which it is, and the chief desideratum is that the colour should be warm and lively. If it is too red, one has only to put a little lime-water or soda into the dye-bath and the desired bluish shade will result. If, on the other hand, the colour is too blue, a little dilute tin-salt will put matters right.

Orchil extract is what is most used nowadays. It is a watery extract of orchil which has been evaporated to a convenient consistency. It is thick-flowing and either violet-blue or red. The buyer specifies which of the two kinds he wants.

Lac Dye.

Lac dye is a red colouring matter extracted from stick lac. It was first made by Stephens in India. It became known in Europe in 1796. Bancroft takes the first place in calling attention to this dye, and his were the earliest recipes for using it published. The product which Stephens first put upon the market, however, was scarcely fit to dye with, and the present product is decidedly better.

Lac dye comes into commerce in the form of a brownish-black dry powder, and is prepared and dissolved by treatment with boiling water and a mixture of hydrochloric and sulphuric acids.

This dye is only rarely used now as its place is better filled by many aniline dyes.

Cochineal.

Cochineal became known in Europe about the year 1526. It is a coleopterous insect. The dye is yielded by the females only. These infest the nopal-plants and are collected after impregnation, leaving a few to form a second brood. They are usually killed by bringing them into hot rooms.

According to Pelletier and Caventon cochineal contains a special red, carmine and various other substances. Cochineal is not so much adulterated now as it used to be when it was much dearer, but cochineal dust and leaves are still mixed with the good cochineal, as well as earth, which can be detected by levigation with water. To increase its weight, cochineal is sometimes kept in a damp place where it becomes from 8 to 10 per cent. heavier. The buyer, however, can easily detect this by the peculiar smell which the cochineal acquires at the same time. Cochineal must always be kept in a dry place. It used to be much used in dyeing ivory, but to-day the cheaper red anilines are used instead. Carmine, however, is still always made from cochineal.

Saffron.

Saffron (*Crocus sativus*) is a perennial shrub growing wild in many Eastern countries and also in Sicily and some parts of Italy, Spain and Turkey. It is also cultivated with much industry in fields and gardens, and made much better than the wild kind. It is a favourite garden plant on account of its beauty and the constantly changing hues of its flowers.

Saffron, as it comes upon the market, consists of threads, twisted and entangled in all sorts of ways. Single threads taper from one end to the other, with three notches at the

thick end. The colour is dark red or reddish-yellow, and whitish-yellow at the thin end of the threads, which are about an inch long, and lustrous. Saffron is adulterated in many ways; with safflower, long-cut pomegranate flowers, marigolds, etc. Such falsifications are known by the threads of the adulterants being whitish or only pale red or yellow, and not showing the tapering form characteristic of the threads of the genuine saffron. One very crude method of adulterating saffron, *viz.*, with boiled smoked beef, produces blackish threads in the sample, which, when burnt, give out the characteristic odour of burning horn. A saffron which has already been exhausted with spirit is too pale in colour and feeble in odour. Its dyeing powers are small, and the single threads are of the same colour all over. Such a fraud is easily detected if the sample is compared with pure saffron, although it is not so easy when some genuine saffron has been put with the exhausted article.

Annatto.

Like orchil, annatto is produced by the chemical action of a sort of fermentation from the marc of the ripe seed capsules of the tree. These are crushed with water, and left for weeks or even months until a violet-like smell is developed. The mass is then pressed out, the annatto is allowed to settle, and the supernatant water is poured off. The annatto is then boiled with constant stirring to a thick paste, which is dried in the shade. It is then packed for sale in the leaves of the tree.

Good annatto has a warm red colour, occasionally brownish-red, and its colour is duller outside than inside. Its smell is like that of urine, with which it is watered in the warehouses. From a solution of annatto in alkali alum precipitates the colouring matter of a dark brick-

red colour, while tin-salt gives an orange precipitate, and ferric sulphate a brown one. The precipitate with acetate of lead is a pale brick-red, and that with sulphate of copper yellowish-brown. Annatto is very little used as the colours got with it are very fugitive.

Safflower.

We call by this name the petals of an Oriental plant which is now cultivated in Spain, France, Hungary, Germany, the East Indies, South America, etc. Its botanic name is *Carthamus tinctorius*. The petals are plucked as soon as fully grown, and mashed up to a paste with water to get out the yellow pigment from them. The yellow water is poured off, and the residue is washed several times with water, and finally pressed and dried. In this way the yellow pigment is got rid of in the main, leaving the red which is wanted. The value of a sample depends upon how much of the red it contains, and is ascertained by crushing a known weight of it with water, adding carbonate of soda, and precipitating the dye on the material to be coloured by means of citric acid. The value of the sample is then judged by the intensity of the colour.

The red colouring matter of safflower is called carthamine; it is insoluble in water, but soluble in carbonate of soda or potash. It is only slightly soluble in alcohol to a pink solution. Light rapidly destroys carthamine, so that it would never be used except for the extreme beauty of the shade it produces.

Fustic.

This wood comes from the West and East Indies and Brazil. The tree is *Morus tinctoria*, which also grows in the Antilles, splendidly in Tabago. It is a large, fairly strong tree, with a hard but brittle and easily split wood.

The wood is light or brownish-yellow and traversed by red veins, and comes on the market in chunks weighing 40 lb. and upwards. The finer the yellow of the wood and the more red veins it has the better its quality. The best of all is Cuba fustic. Next come Jamaica and Porto Rico wood, and then the Brazilian sort. Rasped up fustic which has been long exposed to light and air suffers thereby just as the extract does under the same circumstances.

If the wood is well boiled in water it colours it reddish-yellow, which becomes an orange-yellow on dilution with more water. Acids produce in the decoction a greenish-yellow light precipitate, which is turned to a dark reddish-yellow by alkalies or common salt. Alum and tartar act nearly the same as acids, but the precipitate is of a lighter yellow. Ferrous sulphate turns fustic decoction brown, and tin solutions give no yellow precipitate with it. Glue-water throws out from the decoction a dirty yellow colouring matter, while a purer and finer yellow colour remains in solution.

The colours given by fustic with alum, tartar, tin-salt, acetate of alumina and acetate of iron, are certainly inferior in brightness to those produced by weld, but they are faster. Fustic gives a fast Nankin yellow with chromate of potash, and olive and brown shades with acetate of iron.

Fustet.

Fustet or young fustic is the wood of a tree growing wild in South Europe, but which is cultivated in the South of France. The wood comes from Dalmatia in barked logs which are yellow inside. The yellow colouring matter, got by evaporating the decoction, is a lustrous greenish-yellow mass with an astringent taste and soluble in alcohol and water to a greenish-yellow solution. The solution is precipitated by gelatine and is turned purple by caustic

potash, but the purple soon changes in the air. Alum and tin-salt deepen the colour. Acetate of lead or copper precipitates the dye in red flakes. Ferric sulphate colours the solution a light olive-green, and throws down a brown flocculent precipitate. Decoction of fustet is of a brownish-orange colour, has a feeble smell, a sweet astringent taste, and shows the following tests:—

With isinglass solution . . .	dirty yellowish-red flakes.
„ caustic potash solution . .	fine red colour, but no precipitate.
„ ammonia solution . . .	yellowish-red.
„ tin-salt solution . . .	orange-red flakes.
„ alum solution	a slight yellow precipitate.
„ lead acetate solution . .	yellowish-red flakes.
„ copper solution . . .	chestnut-brown flakes.
„ ferric sulphate solution .	greenish-brown flakes.

Quercitron.

Quercitron is the bark of the black oak, *Quercus nigra*, which grows wild in North America, and has lately been introduced into France and Germany. Chevreul obtained the colouring matter of quercitron in crystals, and called it quercitrine. The bark also contains a dun-coloured tannin which can be easily precipitated out of the way with lime-water or gelatine. Quercitron is even to-day one of the most important yellow colouring matters. It is richer in pigment than any other dye-wood, and produces brilliant and durable colours. As, however, in the tree the colouring matter is practically confined to the inner bark, the technical preparation consists in freeing that as well as possible from both what is outside the inner bark and what is inside it. To judge of the quality of quercitron, the colour is noted, its freedom from wood, and that its outer colour should be always pale yellow, not grey with a yellowish shade. Finally, the woody parts should not be in long bast-like pieces.

Like fustic, quercitron also comes on the market as an extract, both a liquid and a solid extract. Details of the extraction process will be found under logwood.

Another important dye from quercitron bark is flavine. It has sixteen times the colouring power of quercitron bark. It comes upon the market in the form of a fine dark yellow powder, and is dissolved in boiling water.

Turmeric.

This is the name given to the root of an East Indian plant. It contains a yellow and a brown dye, as well as gum. The yellow dye, when pure, looks yellow in small quantities, but in large masses appears cinnamon-brown or reddish-brown. It becomes damp when exposed to the air. It is only difficultly soluble in water, but readily soluble in ether, alcohol or essential oils. Hence even repeated boiling with water leaves a considerable amount of pigment still in the root.

Alkalies turn turmeric to a yellowish-brown and dissolve it. Acids reprecipitate it with a lighter colour. Strong concentrated mineral acids, and also phosphoric acid, redden both the pigment and its tincture. The addition of water destroys the red and precipitates the pigment. Green or blue vitriol gives a yellowish-brown precipitate with turmeric decoction, and arsenious acid a pomegranate yellow. Tincture of turmeric gives with tin-salt a reddish-yellow, with sugar of lead a chestnut-brown, and with ferrous sulphate a dark brown precipitate.

Turmeric is unfortunately not very fast to light. Otherwise, its convenience in use would secure for it far greater employment.

Weld.

All the parts of *Reseda luteola* when boiled in water give a decoction which is yellow, and assumes a greenish cast

on dilution. The plant grows wild all over Europe, and is cultivated in several parts of France, Germany and England. Good weld must have a yellow or greenish-yellow colour, and have plenty of leaves and flowers. The thinner the stalks are, too, the better the weld. French weld is the sort most prized. Acids make weld decoction paler, while alkalies, common salt, and sal-ammoniac darken it, and, in excess, cause a dark-coloured precipitate. Decoction of weld gives with alum or tin-salt a beautiful yellow precipitate, with ferrous sulphate a blackish-grey one, and with blue vitriol a greenish-brown precipitate.

A painter's colour is made from this, and also from the two preceding colours. This is done by mixing the decoction with alum, and then adding levigated chalk a little at a time till all the yellow is precipitated. The colour is much finer if the tannin is removed first of all, which can best be done with glue. Various plants were formerly used as substitutes for weld, but are now disused.

Persian Berries.

Many kinds of these are on the market. They are all very much alike and about as big as peas, angular, heart-shaped, and contain little hard seeds in several compartments. The taste is bitter and unpleasant.

A decoction of Persian berries has a greenish-yellow-brown colour, is very bitter, and behaves to re-agents as follows. It gives—

With gelatine solution . . .	slight turbidity, flaky precipitate.
,, caustic potash or ammonia solution . . .	greenish-orange, but no precipitate.
,, tin-salt solution . . .	greenish-yellow.
,, alum solution . . .	weakens the colour.
,, sugar of lead solution .	precipitate only after 15 minutes.
,, copper acetate solution	dirty yellow-brown precipitate.
,, ferrous sulphate solution	olive-green precipitate.

Barberry Root.

In the root of *Berberis vulgaris* is a yellow dye which has been isolated by Buchner and Herzberger and named berberine. It imparts a yellow colour without any mordant, but the yellow comes out faster and more brilliant if the material is first mordanted with tin-salt. Berberine is only little used.

Indigo.

The fast blue dye known as indigo was imported from Asia in the earliest times, and, since the middle of the sixteenth century when the Dutch began to bring it to Europe after the discovery of the Cape passage to the East Indies, its use has become more and more universal in spite of the prohibitions which were laid upon it by the various Governments. Indigo was thought to be a much less durable pigment than woad, which was at one time the only blue dye available.

Indigo comes from *Indigofera tinctoria*, a common indigenous plant of India. It has been introduced from India into the West Indies and America. To-day there are many qualities of indigo in the market, which are named some after their place of origin and some from their colour, and which have little interest for us in comparison with artificial indigo, which is one of the latest achievements of present progress. Nevertheless the price of artificial indigo is still too high to enable it to drive the natural product out of the market. It must be remembered that some natural indigo, such as Java indigo, contains as much as 85 per cent. of colouring matter, and that natural indigo contains other bodies, such as indigo-red, which are of great use in certain dyeing processes.

Indigo comes into commerce as a dry dark blue powder,

having a violet and coppery shade. It is very fragile, and has a fine smooth uniform fracture. A very important property is that the coppery lustre is increased by rubbing with the nail. Those samples which receive the most lustre by this means, have the smallest specific gravity (indigo is sometimes lighter, sometimes heavier than water) and the finest dark violet colour, are the best. Accurate estimates must be obtained by dyeing tests or by titration with permanganate.

Indigo is insoluble in water, dilute sulphuric acid, hydrochloric acid, or any other acid that will not destroy it. It is also insoluble in alkalies, ether, and in volatile oils. Hot alcohol dissolves a little, according to Chevreul, to a fine blue solution. On cooling, however, it gradually precipitates almost entirely.

Indigo dissolves in cold oil of vitriol to a blue solution. It is best to take four times as much vitriol (by weight) as indigo. Heat is evolved, the mass swells up, and a blackish-blue syrup is formed, which, after about ten hours, will give a blue solution in water. Nordhausen sulphuric acid dissolves indigo much more quickly and better than the ordinary acid. If the solution of indigo in the acid is neutralised with carbonate of soda or potash it remains blue, and only a part of the indigo is reprecipitated in the form of indigo-carmine, or, better, sodium or potassium sulphindigotate. Alkalies and alkaline earths will only in very small measure separate sulphuric acid from its combination with indigo, and many neutral salts will do as much, *viz.*, sal-ammoniac, common salt, alum, etc.

Logwood.

The native country of this tree (*Hæmatoxylon Campeachianum*) is Mexico, and formerly especially that part of Yucatan called Campeachy, from which it derives its name.

From there it was introduced first into Jamaica, and then into other of the West Indian Islands.

The inner close-grained heavy wood is known as logwood or Campeachy wood. It is received in large masses of a yellowish-red colour inside, of rugged surface, and, owing to exposure to the air, of a blackish or blood-red colour outside. Transverse sections show small dark red wavy rings. The wood is very close and firm, is difficult to cut, and is heavier than water. When chewed it dyes the saliva a reddish-brown. The smell of the wood when ground or rubbed is slightly violaceous, and its taste is sweetish and slightly astringent, leaving a bitter after taste.

On boiling with water, logwood gives a deep red decoction. The colour is deepened by acids, and turned violet by alkalies and metallic oxides and their basic salts. Spirit also extracts the colouring matter.

Logwood is classed as splitting unevenly or evenly. The former is the better kind. Honduras wood is of less value, and Jamaica wood with an even surface (because it is sawn) is the worst. The logwood coming on the market in a rasped up or ground state is often adulterated with other wood or with the bark of the hæmatoxylon, and it is hence advisable to cut up one's own wood. To compare samples of logwood, they are treated in the same state of subdivision with equal quantities of water, and the colours of the infusions are compared after half an hour. That which shows the most colour shows the best wood. Pure water is coloured yellow by logwood, but hard water becomes first purple-red, then violet, then blue. Acids give a red colour, finally passing to yellow.

Logwood is usually wetted with water two or three weeks before it is used so that the colouring matter can develop better. This operation is called "ageing" The rasped logwood undergoing the process must be kept in a dark place.

Logwood decoction gives:—

With alum solution . . .	a blue precipitate.
,, tin-salt solution . . .	a blue precipitate.
,, nitric acid	it becomes paler and yellower, and a yellow precipitate forms on standing.
,, ammonia	the colour becomes reddish-blue and dirty on standing.
,, ferric chloride . . .	a dark yellowish-brown or dark violet-blue precipitate.

Logwood extract is now more used than the wood itself, for it is for most purposes cheaper and better to work with. Large factories are employed in making it. There is a liquid and a dry extract. The former is sold in casks, the latter in cases. Ordinary extract is three times as rich in colouring matter as the wood. Besides these extracts there is another market article, the so-called hæmateine, which is the name of the colouring matter itself, but the powder known in commerce by the name is rarely more than the dry extract of the wood.

In spite of the coal-tar dyes logwood is still largely used with iron or chrome for black dyeing.

Cutch.

Cutch or catechu is an extract from decoctions of various plants. Its origin has not long been known. The commercial article is of two kinds. One is from *Acacia (Mimosa) catechu*, a small tree growing in Canara and Behar. The tree is cut down when the flow of sap is most vigorous, and barked. The wood is cut up small, and boiled in a narrow-necked vessel till half the water is evaporated. The decoction is then evaporated completely without straining in wide earthen pans. The mass is left to stand a day and dried in the sun, being constantly turned over. The extract is finally spread on cloths, pre-

viously plastered with ashes and cow dung, and cut into quadrangular pieces, which are fully dried in the sun.

The darker the wood is the darker should be the extract. The quadrangular pieces of extract coming on the market are of a uniform dark brown colour with an irregular fracture and a slight waxy lustre something like opium. It often contains small air bubbles. It has a burnt smell, but not very pronounced. It is gritty to the teeth. The taste is astringent. The dry powder is a dark coffee brown.

The second sort of cutch comes from the catechu palm, one of the finest in the East Indies. Its fruits, the size of an acorn or small plum, are much used, with betel leaves and a little lime, for chewing. The extract is made from these nuts by decoction and evaporation.

Many sorts of cutch are recognised, but the difference is merely in the method of preparation, and chiefly depends on whether earthen or iron vessels were used.

Besides the above two cutches there is a yellow kind (gambier) which consists, as a rule, of inch-long dice-shaped pieces. In spite of the fact that brown cutch is usually dearer than gambier, dyers always prefer the former, which is the more remarkable as the brown kind is often made from the yellow. Such cutch is called prepared cutch, and is made by simply fusing the yellow cutch over a gentle fire and adding to it 1 per cent. of its weight of chromate of potash, so that the cutch is partly oxidised.

A good cutch must not contain more than 3 per cent. of bodies insoluble in boiling water, and must be uniformly dark brown and close in grain, with a smooth conchoidal fracture having a greasy metallic lustre. Cutch may be known from gall-tannin by being more soluble in water, and being soluble in alcohol. It gives an olive-green precipitate with iron, and its gelatine compound gradually turns brown. The following reactions are shown with a 10 per cent. solution of cutch :—

Colour of aqueous solution: reddish-brown.
Acids make the colour paler.
Alkalies make the colour darker.
Proto-sulphate of iron gives an olive-brown precipitate.
Ferric sulphate gives an olive-green precipitate.
Copper sulphate gives a yellowish-brown precipitate.
Aluminium chloride gives a brownish-yellow precipitate.
Bichromate of potash gives an abundant brown precipitate.
Acetate of lead gives a salmon-coloured precipitate.
Alum makes the solution paler.

Gall Nuts.

These are excrescences formed on the leaves of various oaks by the sting of an insect. Two sorts are usually distinguished in commerce, the black and the white—the Asiatic and the European. Their chief constituent is tannin, of which the best kinds contain as much as 65 per cent. This tannin hardly changes solutions of ferrous salts, but gives a bluish-black precipitate with ferric salts. A decoction of galls gives:—

With tin-salt	a yellowish precipitate.
,, alum	a yellowish-green precipitate.
,, copper acetate	a chocolate-brown precipitate.
,, ferric sulphate	a bluish-black precipitate.
,, sulphuric acid	a dirty yellow precipitate.

Sumach.

Sumach is the powder of the young twigs and leaves of a shrub which grows wild in the Levant and in South Europe, and is also cultivated. Sumach contains gallic acid, tannin, and a greenish-yellow colouring matter, probably consisting partly of chlorophyll. A 10 per cent. solution of sumach has a very strong smell, an astringent taste, and gives the following tests:—

With gelatine	. an abundant white precipitate.
,, alkalies in excess . .	. a greenish or reddish-white precipitate.
,, weak acids .	. a slight turbidity.
,, lime . .	. a white precipitate, turning green or red on contact with the air.
,, alum . . .	. an abundant pale yellow precipitate.
,, ferric sulphate .	. an abundant flaky blue precipitate.
,, tin-salt .	. an abundant yellowish-white precipitate.
,, copper acetate . .	. a yellowish-brown precipitate.
,, lead acetate . .	an abundant white precipitate.

Knoppern.

Knoppern or acorn galls are acorns which have become misshapen from the sting of a wasp. They have a dark brown colour and irregular shape, and enclose the eggs and pupæ of the wasp. When these have escaped the galls are very light and not of much use. They come from Hungary and the neighbourhood. They are richer in tannin than oak bark and equal in that respect to gall nuts.

A solid extract of them is on the market, but it is only used for tanning hides.

V.

ARTIFICIAL PIGMENTS.

White-lead.

Lead oxide forms with carbonic acid a beautiful white compound known in commerce as white-lead, and prized for its pure white colour, its durability, and especially for its body, in which it exceeds all other whites. Rubbed up with oil it serves for grading other colours, and forms the basis of all mixed pigments, because it gives durability and a fine lustrous appearance. Various kinds of white-

lead are known, varying according to the method of manufacture.

There are other whites having nothing to do with white-lead, *e.g.*, Spanish white, which is simply oxide of bismuth, and has a brilliant white colour, but is blackened by light and sulphuretted hydrogen. Zinc white has not the fine pure colour of white-lead, but is not so easily browned by sulphurous fumes.

Commercial white-lead is often adulterated with barytes, gypsum, or chalk. The two former are left undissolved on the addition of nitric acid or acetic acid. The last is detected if the concentrated solution so obtained is treated with hydrochloric acid or solution of common salt, which will give in the liquid, whether adulterated or not, a white precipitate of lead chloride. Hardly any lead will be left in the solution which is filtered off and evaporated down. If it gives a deliquescent residue (calcium chloride), there was chalk in the original white-lead. Another way is to precipitate the nitric acid solution of the suspected white-lead with ammonia. The lime remains undissolved, and can be detected by precipitation of the filtrate with carbonate of potash. Sulphuretted hydrogen can be used to throw down the lead instead of ammonia. It is said, too, that bone earth is sometimes mixed with white-lead. This adulteration is detected by the ammonia used as above for precipitating the lead remaining in solution as phosphate if bone earth was present. If the filtrate then evaporated be ignited, a residue is left of glacial phosphoric acid. Every 40 grains of this correspond with 100 of bone earth.

Sometimes, too, it is said, sulphate of lead and chloride of lead are substituted for white-lead, but they are at once detected by their insolubility or difficulty of solution in nitric acid. If the residue dissolves in hot hydrochloric acid, it is lead sulphate.

Naples Yellow.

Naples earth or Naples yellow is an antimonious lead salt, which has a light or dark yellow colour, according to the proportion between its ingredients. Passeri has given the following variations which in the order given pass from light to dark yellow:—

Antimony	4,	Lead	6
,,	4,	,,	7
,,	4,	,,	5
,,	4,	,,	3
,,	2,	,,	4
,,	2,	,,	3

There are also additions of from 8 to 12 per cent. of tartar, or 6 to 12 per cent. common salt, or of 8 per cent. of alum and sal-ammoniac. The two metals are calcined separately and the oxides mixed, or they are alloyed together and the alloy calcined. The oxides are mixed with the other ingredients, finely powdered and sifted, and the whole is calcined in shallow vessels and then ground.

Naples yellow is very valuable in the painting of glass, porcelain and earthenware. For use as a water-colour on wood it is rubbed up with gum water, which gives it a more golden shade. For rubbing up this pigment a very hard marble is required, and it must be worked with an ivory spatula. An ordinary stone slab or an iron spatula will spoil it by making it green. Calcium tungstate has been tried as a substitute for Naples yellow. It is boiled with hydrochloric acid, and reprecipitates when cold, and is then washed with water. Of late chrome yellow has replaced Naples yellow almost entirely.

Red-lead.

Red-lead is prepared on a large scale by calcining moderately damp and finely ground and levigated massicot for

48 hours in a reverberating furnace, and constantly stirring it the while so as to bring every part into contact with the air. As soon as it has assumed the characteristic beautiful colour of red-lead, all openings are stopped, the fire is drawn, and the furnace is allowed to cool. The longer this takes, the better the red-lead will be. The cold mass is sieved through a fine hair sieve (enclosed in a box, to preserve the health of the men employed) to separate the red-lead from unchanged massicot.

Red-lead is chiefly used as a ground colour to be followed by a coat of cinnabar. For this purpose the pigment is rubbed up with drying oil. The first coat usually consists of red-lead alone, the second of equal parts of red-lead and cinnabar, and the third of cinnabar alone. It is also used as a distemper colour, and as a basis for gold or silver colouring on glass, and also for gilding and silvering other things, and also to impart drying qualities to linseed oil. In using red-lead as a pigment care must be taken not to rub it up too long with water, or it will lose all its beauty and get quite pale. Hence the pigment is best got finely divided by levigation.

The deep red of red-lead has a yellowish shade on account of unseparated massicot. When rubbed on paper with the finger it is nearly yellow. It consists of extremely minute scales, is destitute both of smell and taste, and insoluble in water. At a strong red-heat it loses oxygen and becomes litharge. Even in sunlight it blackens and loses oxygen. Heated on charcoal before the blowpipe, it is reduced to metallic lead. This is a sure way of detecting adulteration with brick dust, which remains unchanged in the process, and will not dissolve in acetic acid.

SMALTS.

Smalts or zaffre is chiefly used as a washing blue, being added to the starch, and also for colouring glass and porce-

lain, and as a pigment. As a glazing colour for porcelain and glass cobalt oxide has now, however, the preference. It is sold by the Saxony Smalts Works. Smalts is an indestructible pigment used with boiled oil on wood for fresco-painting and for house-painting. It is a glass coloured blue by oxide of cobalt, and contains a little arsenic. It is put on the market in fine powder. It is got by fusing together sand, potash or cobalt oxide, and breaking up and levigating the resulting glass. The cobalt ores are sorted, the nickeliferous ones are removed, and the rest are roasted to free them from arsenic and water, to further oxidise the cobalt and to make the substance fit for vitrification. It is then ground and mixed with more or less sand. It then can already be used for colouring glass blue, and is sold under the name of zaffre.

Smalts is classified in a variety of tints and qualities, and these again, according to the shade and degree of fineness, are styled by various names and marks. The finest marks of all are always called azure blue or king's blue, and eschel comes next. Smalts is used in the many ways already mentioned. If it is to be used for walls it must be rubbed up fine with spirits, and stirred up in glue-water. Ordinarily smalts should not be used with boiled oil as it then readily turns blackish. A very beautiful blue, almost equal to ultramarine, is Thenard's blue. This blue, which can be used for every kind of painting, shows the greatest resistance to all manner of external influences, and of a warm colour almost surpassing the darkest ultramarine, used to be much used as a substitute for that pigment; but the ultramarine is now restored to its former position by having become cheaper. King's blue, Thenard's blue, cobalt, and ultramarine are scarcely used now except in the pottery trades, for in that artificial ultramarine cannot replace them as it cannot be fused with

borax or lead glass fluxes without losing its colour from chemical change.

Stannate of cobalt (coeruleum) is hardly ever used.

Ultramarine.

In describing this beautiful blue pigment we have naturally for our purposes the artificial product in view. Since success has attended the efforts to produce it on a large scale, the natural mineral is hardly ever sold, and finds room only in museums.

In general, natural ultramarine has the properties and the composition of the artificial product, but shows some chemical differences from it. The principal of these is the ease with which the artificial product is decomposed by acetic acid and alum, re-agents which do not affect the natural mineral. The rapid decomposition of artificial ultramarine by acetic acid is attended with the evolution of sulphuretted hydrogen.

Artificial ultramarine can be used as a water-, fresco-, or oil-colour. It resists the effects of air, light, water, and is not blackened by gas, but acid vapours destroy its colour. It is quite fast to alkalies.

Towards acetic acid and alum the various commercial artificial ultramarines behave very differently. Some are destroyed at once, while others resist for a time, especially alum. They all have one property in common, *viz.*, to absorb water from the air. Under unfavourable circumstances they may come to contain 5 per cent. of water, or even more. It is by no means easy to compare two samples of ultramarine with regard to body, independently of shade, and merely by the appearance of the pigment. The best plan is to rub both to the same degree of fineness, and then to mix both with the same known proportion of gypsum. Naturally the sample which requires the most

gypsum to produce any given change of shade is the better of the two. Besides it has been proved that ultramarines which will bear the most admixture with alum or alumina without much change in colour are much better in other respects for certain purposes, such as paper-dyeing. Here the ultramarines rich in silica are more permanent than the poorer sorts. To detect whether a pigment is an ultramarine, treat it with hydrochloric acid, and if it is ultramarine sulphuretted hydrogen will be at once evolved.

CINNABAR.

Although cinnabar is very common in nature, it is also made artificially. It is in much use as a pigment, especially for sealing wax. Holland used to be the principal seat of the manufacture of cinnabar, where it was sublimed in large pots over an open fire. Even to-day it is often made by fusing 4 lb. of sulphur in an unglazed earthen vessel, and then pouring in little by little 25 lb. of quicksilver, previously heated in a crucible or an iron spoon. The two elements combine with the evolution of so much heat that the mass glows. At this point the vessel is immediately covered with a lid to exclude the air. If, however, the lid is put on before the mass glows, the arrival of that stage would cause a violent explosion which would shatter the apparatus. The black non-metallic mass is finely powdered and then gently heated to drive off uncombined sulphur, and then more strongly heated to sublime the cinnabar. Care must be taken to confine the fire to the bottom of the subliming vessel, or the whole of the cinnabar will escape in vapour, and if the sublimation is done in glass, the vessel may be fused. If the heating is continued for a time after the sublimation is finished the cinnabar becomes a finer red. The final product is a dark red mass of a greyish-violet metallic lustre

having a crystalline fracture. Finely powdered, it becomes a very deep red.

Good cinnabar comes on the market in masses consisting of radiating needles of a greyish-violet metallic lustre, which give a deep red powder. The beauty of the colour ought to be distinctly increased by rubbing the cinnabar up with very dilute nitric or acetic acid. Adulteration with dragon's blood, red-lead, or similar substances can only happen in prepared cinnabar, and is easily detected. Red-lead impairs the beauty of the red and makes it verge towards a pomegranate colour, which is made much darker when the sample is treated with nitric acid, on account of the formation of peroxide of lead. Acetic acid boiled with such adulterated cinnabar acquires a sweetish taste, and the property of giving a black precipitate with sulphuretted hydrogen. Dragon's blood causes the cinnabar to redden spirit of wine, and when the sample is thrown on the fire, produces a balsamic smell. Brick dust or red ochre makes the cinnabar colour hydrochloric acid yellow, and will not sublime. Red arsenic makes the pigment exhale a garlic-like smell when thrown on the fire.

Berlin or Paris Blue.

This blue (best known in England as Prussian blue) is much used as a brush-pigment, not on walls, but on woodwork, and combined with suitable yellows to make greens, etc.

The finest sort (called in England Chinese blue) is got by dissolving a neutral pure ferric salt and adding ferrocyanide of potassium, when the Berlin blue is precipitated with its characteristic beautiful colour. It is filtered off, washed, and dried in the form of small sticks. Another very common method is to dissolve a copper-free green vitriol which has oxidised in the air, *i.e.*, a mixture of

ferrous and ferric sulphates, and then to add alum. The mixture is then precipitated with ferro-cyanide of potassium. As the pigment so prepared is rather of a light blue owing to the ferrous salt, and still lighter on account of the alumina precipitated with it, the precipitate must be stirred up for a long time before filtration to darken. When the precipitate has fully settled it is washed on a linen filter, and brightened by rubbing up with water and boiling for a few minutes in a copper vessel with nitric acid, and then mixing it thoroughly with concentrated sulphuric acid. It is then left for a day or two, and then washed, pressed, moulded into pieces, and dried, first in the shade in the open air, and then in a drying-room at from 70 to 80 deg. C. It is then allowed to cool very slowly.

The purest Berlin blue is dark blue, and has a coppery lustre like indigo, a brilliant lustre, and a conchoidal fracture. If the fracture is dull and earthy, or it does not easily give a full tint when rubbed on paper, it is too hard and impure. Berlin blue has no smell or taste, does not moisten in the air, but is for all that very hygroscopic. It is insoluble in water or alcohol and is decomposed both by acids and by alkalies.

Orpiment and Realgar.

Although both these substances occur in nature, orpiment in crystalline plates of a beautiful lemon-yellow colour, realgar in greasily lustrous orange masses with a conchoidal fracture, yet for use in the arts they are for the most part artificially prepared. Both are much used in painting, more with oils than in water-colour, and give valued yellow and orange-red hues. They are also used in the manufacture of yellow and orange-coloured varnishes.

Orpiment may be made either in the wet or in the dry way. The first consists in fusing together and then sub-

liming a mixture of sulphur with seven times its weight of white arsenic in iron vessels. This sublimed product consists of yellow crystals. The second method is carried out by precipitating a solution of arsenious acid or an arsenite in dilute hydrochloric acid with sulphuretted hydrogen, when the orpiment goes down as a beautiful yellow precipitate.

Realgar is prepared by heating arsenical pyrites with sulphur to a red heat in large earthen retorts. At the end of the operation the receivers attached to the retorts contain a mixture of red and yellow arsenic with glassy realgar. The last is subjected to a special refining process by remelting in cast-iron pans, and removing the resulting slag. The purified mass is made of the right colour by adding sulphur if too dark, and by adding very dark realgar if too light. It is cast in cylindrical wrought-iron moulds, and after it has set it is broken up and packed.

Artificial realgar is brownish-red and opaque, has a greasy lustre, and is insoluble in water or spirit. It is soluble in caustic alkalies. By heating it becomes darker and then fuses, and finally burns with a whitish-blue flame. It can be sublimed unchanged.

Orpiment made in the wet way is an amorphous powder, but the sublimed compound consists of plates having a subconchoidal fracture. Orpiment is also called king's yellow. It is tasteless and odourless, insoluble in water or spirit, but dissolves in caustic potash, forming potassium arsenite. Nitric acid or aqua-regia dissolves it with decomposition.

Chrome Green.

This is used both for an oil-colour and in the preparation of green lakes, and also for glass and porcelain. The substance is chromium sesquioxide, and is now made in a great variety of ways, *e.g.*, by igniting the hydrated oxide,

by heating mercurous chromate, or by treating bichromate with starch, sugar, carbon, or with a mixture of sal-ammoniac and carbonate of potash. The last process is due to Wöhler and gives a beautiful green. The heat is kept up till all excess of sal-ammoniac is volatilised, and the residue of potassium chloride and chrome is lixiviated with hot water, which dissolves out the potassium salt.

Chrome is a rather dark green powder, infusible, and unchanged even by a red heat. To its power of standing heat it owes its use in making green glass and porcelain. Easily soluble in acids, it becomes insoluble by heating to redness. With water it forms a greyish-green hydrate, which loses its water at a dull red heat and forms the dark green anhydrous sesquioxide. The salts of this oxide are green and have an astringent taste. Ammonia precipitates the hydrated oxide from their solutions.

Chrome Yellow, Red and Orange.

These are used both as oil and as water colours. According to Pubetz we have:—

(*a*) Neutral lead chromate (chrome yellow).
(*b*) Basic lead chromate (chrome red).
(*c*) A mixture of both (chrome orange).

Chrome yellow is got in three ways:—

1. By precipitating sugar of lead with bichromate of potash.
2. By treating lead sulphate with a warm solution of yellow neutral potassium chromate.
3. One hundred lb. of recently precipitated lead chloride are digested with 47 lb. of lead bichromate.

This chrome yellow is much warmer and more beautiful than the others.

Chrome red is prepared:—

1. By fusing neutral lead chromate with caustic potash or saltpetre. Half the chromic acid goes from the lead to form chromate of potash.
2. By fusing a mixture of saltpetre and nitrate of soda, and adding to the fused mass little by little neutral lead chromate. The mass is then allowed to cool, and lixiviated, and the basic lead chromate left behind is washed and dried.
3. By precipitating a solution of lead acetate with yellow potassium chromate and caustic potash.

Chrome orange is made by boiling chrome yellow with milk of lime.

These pigments are tasteless and odourless powders of various shades of yellow and red which resist both light and air. They are insoluble in water, slightly soluble in acids, and easily in caustic potash. Chrome yellow is not unfrequently adulterated with barytes, alumina, gypsum or lead sulphate. These impurities are at once detected by the use of caustic potash, when they do not dissolve. These chrome colours have, as they deserve by their beauty, durability, body, and the ease with which they can be mixed with other pigments, nearly driven out the other yellow and orange pigments.

Mosaic Gold.

Mosaic gold or bronze when good and genuine is of a beautiful golden yellow, and in soft-feeling scales. Mismade specimens are in much smaller scales, and of a greenish or brownish cast. The pigment is prepared in the dry way by gradually bringing a mixture of 12 lb. of tin-amalgam (one-third mercury and two-thirds tin), 5 lb. of powdered sulphur and 4 lb. of sal-ammoniac in a bolthead to a dull red heat, so that cinnabar and tin-salt sublime out. The bronze remains at the bottom as a scaly, golden shining mass.

As a rule the value of the product increases with the purity of its golden tint and with the fineness with which it is powdered. The inferior kinds are darker and brownish in colour, and are rubbed up much less fine.

Bronze is insoluble in water or acid, except aqua-regia. It dissolves in boiling caustic potash with partial decomposition. It has a greasy feel, and easily loses its colour. At a red heat it loses half its sulphur.

Mosaic gold is excellent for bronzing, and for producing gold-like ornamentation on wood, gypsum, clay, iron and copper. It is largely used in making gilt paper and gilding varnishes, for which purpose it is used with a vehicle of boiled oil.

Green Mineral Pigments.

The best classification and description of these pigments is given by Gentele, but his account would be too comprehensive and diffuse for our purpose. We content ourselves with a threefold classification, excepting chrome green which has already been described.

1. Greens consisting of basic carbonate of copper: oil green, mountain green, and Bremen and Brunswick greens.

2. Greens consisting of arsenite of copper· Scheele's green, named after its discoverer, and also called Swedish or mineral green.

3. Greens consisting of arsenite and acetate of copper· emerald green, otherwise called Paris green. First discovered by a saddler at Schweinfurt; this is sometimes called Schweinfurt green.

1. *Oil Green, Mountain Green, Bremen and Brunswick Greens.*

These pigments are either made by simply crushing natural malachite, an emerald green basic copper carbonate, or by precipitating the same substance with carbonate

of potash from a solution of blue vitriol. Bremen and Brunswick green are made differently. The first is prepared by precipitating carbonate of magnesia and alumina together with the basic carbonate, by adding to the copper sulphate alum and a magnesia salt before putting in the carbonate of potash. Brunswick green is a mixture of basic carbonate of copper with alumina hydrate prepared by precipitating with ammonia a mixed solution of basic chloride of copper and alum. In consequence of the method of precipitation it will contain, with the copper salt, carbonate of magnesia and hydrate of alumina. Bremen green, on the other hand, contains only alumina in addition to the copper salt.

2. *Scheele's Green, Mineral or Swedish Green.*

The principle of the preparation of this pigment is precipitating with arsenious acid a solution of sulphate of copper free from iron and carbonate of potash. To this class belong also Vienna, Kirchberger and Neuwieder green, and also Imperial, Mitis, and New green, all pigments which, by numerous changes made in the methods of preparation, and to be discussed later, are made commercially in various shades.

3. *Schweinfurt Green and Mineral Green (Leipzig and Paris Green).*

These pigments are obtained when arsenite of copper is treated with acetic acid and the excess of acid is distilled off, or when verdigris is dissolved in vinegar and mixed with a solution of white arsenic in the same solvent, and the mixture is gently evaporated to crystallisation. These methods give, according to their nature and the details of their execution, various results, so that all Schweinfurt greens are not of the same beauty.

The external appearance of these greens is very various. Sometimes they are small, shapeless lumps, *e.g.*, mineral, Bremen or Neuwieder green, and sometimes occur as a more or less fine-grained powder as may be seen in the case of oil green, mountain green, and Leipzig and Schweinfurt greens. The differences in colour, too, are great, as they are sometimes olive-green, sometimes bluish-green, sometimes yellowish-green, sometimes grass-green, and sometimes light and sometimes dark. They are insoluble in water but soluble in the stronger acids, and unchangeable in the air, but are turned dark brown by heat, owing to the formation of oxide of copper. The finest and most valuable of them is certainly Schweinfurt green. It is above all the others in purity, brilliance and depth. It is very fine-grained, stands exposure to the air well, and can be mixed to a uniform mass with other colours, *e.g.*, white-lead, a property of great importance to the painter.

Ochres and Rouge.

Ochres or bloodstones are found in nature ready made. Ochre may be red iron ochre, or brown iron ochre, or yellow iron ochre, but it is always hydrated ferric oxide, and occurs both in recent and in the older rocks. Bloodstone occurs in red heavy masses which readily leave a mark, and consist of concentric fibres, and is commonest in the later formations.

Red ochre is an intimate mixture of red iron ochre and clay, of a more or less red colour and an earthy fracture, soft, and easily making a coloured mark. This, too, is chiefly characteristic of the later rocks. The chief ochre mines are in Germany (Saxony, Hanover, Bohemia, Steiermark and Silesia), France, England and Spain.

Ochre is an earthy powdery substance of various yellow shades, and the drier, more finely powdered, and deeper and brighter in shade it is, the better its quality. These

remarks hold for all the ochres. Powdered bloodstone has a beautiful dark red colour, the more beautiful the finer the powder. In pieces, as above remarked, it is distinguished by its regular radiating structure.

Rouge is also a powder, of very varied fineness and shade, from a pale red to a dark brownish-red. Red ochre is either brownish-red or blood-red, is soft, earthy, and marks readily. The ochres are free from taste or smell, insoluble in water but readily soluble in dilute acids, unless they have been ignited. The cooled mass combines with water reproducing the hydrate. The oxide of iron is red when anhydrous, but yellow when hydrated.

Cadmium Yellow.

Sulphide of cadmium, called cadmium yellow for short, is a beautiful warm yellow. The chief property of cadmium sulphide, however, next to its beauty is its great fastness to alkalies and soap, and, unlike chrome yellow, it is fast to sulphuretted hydrogen. Chlorine only attacks it at a certain degree of concentration, and light and air only very slowly act on it.

In practice various methods are employed for making cadmium sulphide. It may be generally remarked that it will be purer and deeper in colour the less zinc it contains. The method of manufacture is to dissolve broken cadmium in dilute sulphuric acid. It dissolves quickly with evolution of hydrogen. The cadmium must be in excess, so as to saturate all the acid. The concentrated and neutral solution is then diluted with water and completely precipitated with sulphide of sodium.

It is cheaper and certainly simpler to make the pigment from cadmium nitrate, by fusing that salt with its own weight of sodium hypersulphate, a process which is largely used in the printing of textiles.

VI.

COAL-TAR DYES.

The aniline colours, more correctly the coal-tar dyes, are known to every reader of this book, and it is therefore superfluous to say much on a subject with which we are all acquainted.

For our purpose we will make the following classification of the aniline dyes, beginning with reds and passing therefrom through orange, yellow, blue, violet, green, brown and mixed colours to black. We also classify the single colours according to their method of production into basic, alkaline, and acid, and also into alizarine, resorcin, and benzidine dyes.

Red Dyes.

The red dyes are now sold in very large numbers, and answer all requirements fully, both with regard to shade and lustre, and also on the whole in reference to fastness.

Basic Reds.—These are the oldest coal-tar colours. We mention first fuchsine or magenta (diamond magenta) and rubine, which (as identical dyes) easily colour wood without any mordant, and, unless the bath is too concentrated, give fairly fast colours. When the solution is too strong the red rubs off a good deal, and the use of tannin and Glauber's salt is necessary. Rubine is said to give rather clearer shades than diamond magenta. We may further mention cardinal red, safranine, safranine scarlet, garnet red, scarlet red and coralline. The character of the colour is given approximately by the name.

Alkaline Reds.—Of these I can only mention Dahl's alkali red. Whether this dye is actually used for wood-dyeing I cannot state with certainty. Trials I made

myself with great care, gave quite good results when the solution of the dye, either the R or B brand, was mixed with waterglass, allowed to cool somewhat, and then applied with a brush in the lukewarm state. The colour produced is fast to soap and fairly so to light and air. For cupboards and show-cases the dye is very suitable.

Acid Reds.—These are very numerous, but their fastness is by no means always satisfactory, and the scarlets especially rub off a good deal from wood, as they have little affinity for the fibre.

For the sake of completeness we will mention brilliant croceine, which gives very bright hues. R gives a pure warm orange, but B, M, 3B, 5B, 7B and 9B verge towards blue more and more, so that 9B gives a fine pale garnet shade. For full shades a little alum should be used.

Similar colours are got with new red, scarlet, ponceau, pyrotine scarlet, fast red, orchil red, and many others.

Of the resorcin dyes we have the finest series of reds. They are better known as the eosines, although most of them have other names. I mention eosine pink, soluble in water or spirit. This with lead acetate gives brilliant bluish-pink shades. Rose Bengal is still more brilliant, and is best fixed with neutralised alum. The dye is too dear, however, for very extensive use. Similar to it is phloxine, which is fixed in the same manner. We have also erythrosine, and finally rhodamine. The latter answers well on wood with acetate of alumina. Eosine is often adulterated with fuchsine, coralline and safranine. To test for these falsifications the dye solution is treated with sulphuric acid diluted with four times its volume of water. This separates eosine as an orange precipitate, and the others remain dissolved, fuchsine and coralline yellow, and safranine with a bluish-violet colour.

The reds derived from anthracene form a group sharply divided from all other dyes.

Of the vast number of anthracene dyes few have any interest for us. Only a few, in fact, with very special properties have attained a wide employment. During the last few years alizarine has entirely displaced madder, and extracts of madder are now only made for a few very special purposes.

Alizarine comes on the market as a yellow or brownish paste containing 20 per cent. of the dry substance. We distinguish yellow and bluish shades. The former usually contain flavopurpurine, the latter alizarine.

Commercial alizarine gives reds with alumina, browns with chrome, and violets with iron. All these lakes are fast to light and air. The alizarine is tested to see how much water it contains by drying it at 120 deg. C.

A special class of reds is known as the benzidine dyes.

These are the so-called substantive (*i.e.*, direct, dyeing without a mordant) cotton dyes, which contrast with the previously known coal-tar dyes by possessing the valuable property of dyeing vegetable fibres without a mordant. This affinity with the fibre goes so far, that these dyes act as mordants for others. This property can often be utilised with advantage in the dyeing of wood.

With these red dyes we can get beautiful scarlet and Turkey red shades, especially with Congo red. Congo G and GR give rather yellower shades than Congo. Brilliant Congo has the advantage over Congo in fastness to acids, and shares this property with benzopurpurine 4B and deltapurpurine, but the latter is more sensitive to light. Benzopurpurine 6B is distinguished by its bluish shade, while rosazurine G and B give pure safranine tones. In small quantities these dyes give delicate pinks.

Congo corinth and Congo corinth B serve for producing full dark violet shades.

Bluish-red hues like safranine-red can also be got with Hessian purple, and the best brands are B, NG, and G.

Any number of shades can be got by mixing these with other colours of the same group. All the benzidine dyes should be dissolved in at least 100 times their weight of water to be sure that nothing is left undissolved. If the water is hard it should be softened with soap or soda, and the precipitate should be removed before the dye is added. Most of these dyes require no mordant and are fairly fast to rubbing, but the dyeing is always more satisfactory with a little alkali, whether soda or potash, borax, or waterglass. Only a very little need be used, and in fact the alkaline reaction produced should be only faint. It is essential to apply the colour hot. Beautiful and easily used as the colours of this group are, they all have one great fault, and that is their want of fastness to light and acids. This is so great that a beautiful medium Congo red, for example, is quickly changed and spoiled by the carbonic acid of the air.

Yellow and Orange Dyes.

The first aniline yellow was put on the market in 1864 by Simpson, Maule and Nicholson. It was a light crystalline brownish-yellow powder, but it has not been made for a long time. Before the discovery of the substantive dyes orange and yellow artificial colours were hardly used in our branch, with the exception perhaps of picric acid. We have still, however, a great choice of excellent yellow natural dyes, such as quercitron, flavine, fustic, turmeric, weld, annatto, saffron, etc., which all serve to give fairly fast colours to wood.

One of the most important and the fastest yellow anilines is undoubtedly auramine, which is of great interest to us. Used alone, it gives pure brilliant fast yellows, and it is also used in mixtures for green, red, chestnut, olive, etc., and is an excellent substitute for turmeric,

being much faster to light. As auramine is decomposed by boiling water, it must be dissolved in water which is neither below 50 deg. C. nor above 80 deg. C. Mineral acids destroy the solution instantly. It dyes wood without any mordant, but the results are better if the wood is first mordanted with tannin.

To continue the yellows in order, we next pass to the strongly acid nitro-dyes. First of these is picric acid, formerly the sole example of its class, and which was used for dyeing wood, ivory, marble, etc. But many defects belong to these dyes, such as want of fastness to light, small affinity for the material, and less or greater poisonous qualities (especially in the case of picric acid), and have almost entirely removed picric acid from our list, as well as its congeners, such as naphthol yellow, naphthol yellow S, Victoria yellow, fast yellow, acid yellow, azo acid yellow, etc. Quinoline yellow, although not belonging to the class, is a strongly acid dyeing body, and has the same drawbacks, and is not to be recommended. Much better results are got with tartrazine.

The orange dyes are made by mixing yellows with reds, and there are also single orange dyes. These dyes have only a limited use, and have not the importance of the other dyes such as reds, blues and blacks.

We may mention among basic yellows and oranges mandarin, metanil yellow, methyl orange, chrysoidine, phosphine, aurantia, Martius yellow, etc. They are all soluble in both water and spirit. They are used without mordants and fixed some with Glauber's salt, some with tannin. Phosphine, chrysoidine and aurantia are much used in wood-dyeing, as the fastness of the colour is usually satisfactory. Tannin is not generally used with them.

The largest number of yellows is found among the benzidines, some of which have become practically indispensable for the production of certain shades. They need only to

be applied to the wood with a brush in the state of hot aqueous solution not too concentrated.

Alkali yellow and alkali orange (Dahl) give a beautiful straw yellow, or medium orange. For the best results Glauber's salt should be used. Common salt has the same effect, but although it intensifies the colours it also makes them somewhat muddy.

Fine and very fast yellow chamois shades can be produced with cresotine yellow, of which we have two brands, G and R. The results are particularly fine when the cresotine yellow is mixed with toluylene orange G. Further dyes of this class are chrysamine, Hessian yellow, brilliant yellow, chrysoidine, cotton yellow, carbazol yellow, diamine yellow and thioflavine. They are best fixed with Glauber's or common salt, except brilliant yellow, which is best fixed with oxalic acid. Unhappily all these dyes are loose to light, and for this reason inferior to the basic yellow and orange dyes.

Primuline yellow, which is even less fast to light than the benzidines, is hardly used for our purposes. The development of primuline into the so-called ingrain colours such as primuline orange, golden yellow, golden red, maroon and brown has, so far as I know, not yet been introduced into wood-dyeing.

Last among the orange dyes allusion may be made to alizarine orange or nitro-alizarine. It has not found the same extended use as the other alizarines, but is as fast as alizarine red. It is used in the form of 20 per cent. paste on wood previously mordanted with alum free from iron.

Blue Dyes.

The number of these in use is very great. We use many more blues than reds. For our purpose the following classification is the best:—

Basic dyes.
Acid dyes.
Benzidine dyes.

Many blues having different names are really identical. Blue dyes must be dissolved in soft water, usually in from 200 to 300 times their weight of boiling water. The solution must only be used if perfectly clear, and should be added to the dye-bath through a hair sieve, and the colour comes out much more level if the dye is put in in three or four lots.

The first coal-tar blue was that of Girad and de Laire. It was made from fuchsine and called Lyons blue. Like *bleu lumière* it is only soluble in spirit. Next came the blues soluble in water, one of the first of which was Nicholson's alkali blue, which still occupies a high place among the aniline blues.

Basic Blue Dyes.—Two basic blue dyes which are only soluble in alcohol must first be mentioned: Gentiana and Humboldt blue. Both are made by the Berlin Actien-Gesellschaft. They are said to give shades faster to light than those produced by the dyes soluble in water.

Methylene blue is a basic dye. It is a brown powder which dissolves to a beautiful sky-blue in water, acetic acid or alcohol. Tartaric acid increases the solubility. The following are the various brands:—

Methylene blue RX	the reddest shade.
,, BX	somewhat bluer.
,, BRN	the same shade.
,, BR	greener.
,, X	greener still.
,, R	reddish.
,, B	bluish.
,, G	very greenish.
,, BG	between B and G.
,, MD	a strong colour.

Closely resembling methylene blue and giving exactly the same results is Oehler's ethylene blue.

Ethylene and methylene blues give very fine and fast shades, which have the merit of not rubbing. They give much deeper shades on wood if the material is first mordanted with pyrolignite of iron. The blue is applied warm after the wood has dried. Dark indigo tones of great fastness are thus obtained.

Less brilliant hues can be got with the navy blues (*bleu marine*), which are, however, not so fast as methylene blue.

Other blues very suitable for our purpose and satisfactory in fastness are pure blue, red blue, new blue, opal blue, Nile blue, peacock blue, night blue, Victoria blue, indazine blue, fast blue and indamine blue. For getting a brilliant warm pale blue alkali blue is specially suitable. I would for this purpose specially recommend ammoniacal solution of alkali blue, to which it is a great advantage to add a little Turkey-red oil. Nevertheless, the solution must not be made too alkaline or the wood may be injured. The advantage of using this ammoniacal dye for wood consists in the rapidity with which the ammonia evaporates and leaves the insoluble dye behind. I have found that it gives remarkably warm and lively hues to wood, and have never had any fault to find with it in the matter of fastness.

Of blue alizarines much need not be said. They are difficult to use, and it is hardly possible to make them level. This is the result of the fact that the dye has itself to be formed, which textile dyers do by long boiling or by oxidation. Alizarine blue S, however, is easily used, and gives level shades.

Other blue alizarines, the so-called alizarine cyanines, are hardly suitable for our purpose, although they cause no risk of want of uniformity.

Blue Benzidine Dyes.—We must first mention azo blue

benzoazurine, of which there are various brands. The peculiarity of these dyes is that they look reddish during dyeing, and only become quite blue later. Benzoazurine gives very full indigo shades when mixed with half per cent. of its weight of chrysamine. The mixture is dissolved in boiling water with a little soda, and the solution is used hot. Although the benzidines have multiplied greatly of late their use has not extended, probably because the basic and acid blues are more brilliant in shade, faster to light and more easily used.

Finally, as regards the artificial indigo of the B.A. and S.F. Indigo pure (indigo rein) comes on the market in the form of powder or paste. It is in no way different from refined natural indigo and, like it, contains 97 or 98 per cent. of indigotine. Pure indigo, like natural indigo, is dissolved in sulphuric acid and then diluted with water for dyeing purposes. I would, however, decidedly recommend that when indigo carmine is wanted that it should be bought. One is then sure of a carefully made article. Home preparation is very difficult and easily goes wrong; the indigo is not fully dissolved, and unlevel and dull shades are the result.

Violet Dyes.

The first prepared artificial violet was mauveine or Perkin's violet, and was also called aniline violet, aniline purple and indisine. Perkin was the first chemist to make an aniline dye on a large scale for industrial purposes, and his provisional specification was obtained as early as 1856. His English and French patents expired in 1857 and 1858. He is said to have discovered mauveine by chance in attempting to synthesise quinine.

Mauveine is obtained by oxidising aniline containing toluidine with sulphuric acid and bichromate of potash.

The free base is a black crystalline powder, soluble in alcohol to a bluish-violet solution, and forming with acids a series of salts which are coloured like those of safranine and behave like them chemically. Although mauveine is very fast it is not much used now by dyers.

There followed then various other violets such as dahlia, primula, Hofmann's violet, Dorothea and Paris violet, which were all abandoned later, when makers learned to make violets far exceeding them in beauty and fastness.

Basic Violet Dyes.—The chief representative of these is methyl violet.

This is the violet that is of all the most used for our purposes. It comes into commerce in so many shades that all possible violets can be produced with it. It can be applied on wood without any mordant, but if absolutely clear and non-rubbing colour is wanted it is advisable to mix the solution before use with a little sulphurous acid or bisulphide of soda.

Ethyl violet and crystal violet behave just like methyl violet. The other dyes of this class, gentiana violet, ruby violet and new violet, are less suitable for our use.

Of the acid violet dyes only the acid violets need be mentioned, and of them only the marks 4BN, 6BN and 8B. These are largely used. Care must be taken in dissolving them as they are somewhat difficultly soluble, and any undissolved particles cause unlevel dyeing.

Of the alizarine violets galleine is the one most used, and, to a less extent, anthracene violet. The others are scarcely or not at all employed because they are difficult to handle. Although all these dyes are fast they are not easily fixed on wood.

We only need to mention a few of the benzidine violets as suitable for us. The same objections apply as in the case of the blue benzidines. Only azo violet, Hessian purple and heliotrope are occasionally used. After dyeing the

wood must be carefully cleaned with solution of soda to prevent the colour from rubbing.

Green Aniline Dyes.

Before green artificial dyes had been hit on dyers had to make greens by mixing blues and yellows. A beautiful green was thus made from indigo.

The first aniline green, aldehyde green, came out in 1862. The discoverer was Cherpin, a Frenchman. Later appeared iodine green, also called Hofmann's green. The interest of these is now historical merely. Methyl green, which has almost been abandoned for wood-dyeing, is got by heating methyl chloride with methyl violet. The soluble dye thus obtained is even less stable than malachite green.

When methyl green is in solution in water a part of it is apt to resinify. In consequence only cold water must be used for making the solution, and alcohol should be mixed with it. Temperatures above 80 deg. C. reconvert the dye into methyl violet.

Malachite green, bitter-almond oil green, or fast green is a very beautiful green. It occurs in yellowish and bluish shades, and in powder or in crystals. It can be used on wood without a mordant, or with acetate of alumina or with a mixture of chromium acetate and magnesia.

Brilliant green, new Victoria green and diamond green are new dyes which can be shaded yellow with auramine. The Berlin Actien-Gesellschaft sells a mark of ethyl green and another of olive-green which are closely allied to those already mentioned in the way they are used.

Other beautiful greens are China green and the Elberfeld light green. Specially fine shades are got with acid green, which fixes itself on wood easily and uniformly with a little acetic acid. Very dark green shades always

rub a little, and the wood must always be first mordanted with tannin solution. We have no suitable dye among the benzo dyes. Benzo green cannot compare with the basic greens in brilliancy and beauty.

Anthracene green, usually called coeruleine, an alizarine dye, has only a very limited use in our industry, because it will only give dull shades although they are very fast. Shaded with Persian berries or quercitron, it produces mode shades which may on occasion be extremely useful.

Till very lately coeruleine was sold as a brown 11 per cent. paste, but it is now obtainable as a powder soluble in water (the bisulphide compound). It is best fixed on wood with chromium acetate, and after dyeing the wood is thoroughly washed with weak solution of soda.

Brown Dyes.

The first brown coal-tar dyes were made from the waste by-products of fuchsine manufacture, and some of them, maroon for example, are still made. One of the first proper browns to be discovered was the phenylene brown of Roberts, Dale & Company, Manchester. The most important brown now used is unquestionably Bismarck brown, of which there are two marks, G (yellowish) and R (reddish). Bismarck brown is obtained by fusing hydrochloride of aniline with fuchsine. It dissolves in water or spirit, and the solution dyes wood alone, but better when applied mixed with a little acetic acid. Years passed before Bismarck brown was followed by other artificial browns, but there are now several, of which we may mention Berlin brown, Philadelphia brown and mode brown, which are basic and much like Bismarck brown. We have also fast brown and excelsior brown, which are fixed with a little alum. Vesuvin is, however, better fixed on wood with tannin.

The brown alizarines are numerous and give very fast colours. We can use:—

1. Anthracene brown with acetate of chromium.
2. Alizarine orange with nitrate and acetate of chrome.
3. Alizarine red with acetate of alumina.

Of the benzo dyes I must first mention the benzo brown of the Elberfeld Farbenfabriken. It fixes easily and uniformly, and the wood requires no special washing afterwards to give a pure clear shade. Very beautiful and fast chestnut browns are also easily got with toluylene brown. The colour produced stands soda and soap well and is faster to light than most benzo-browns. Its fastness to acids is also satisfactory. If it has to be used with other benzo dyes that require soda, that base is best used in the form of Glauber's salt. Alkali brown, however, is best used with soda, but it is more difficult to get level shades with it than with benzo brown. Of late some sulphur browns, such as thiocatechin, have been put on the market, which are on trial as regards their use on wood. So far they have not been very satisfactory. The hot solutions have an evil smell owing to the evolution of fumes which, in small rooms, will bleach any already dyed articles that may be there.

Gray and Black Dyes.

Much need not be said about the gray dyes, for most grays are got by diluting black with white. The well-known nigrosine, which is sold in a form soluble either in water or spirit, can hardly be looked on as a gray dye. For our purposes the spirit-dye is always preferable.

More claim to be called gray may be conceded to new gray (Elberfeld). This gives very pleasing grays on wood.

Real black dyes have only been introduced quite re-

cently. At first, blacks were always got by combinations, using logwood, fustic, sumach, ferrous sulphate, bichromate of potash, blue vitriol and other ingredients, so that the black was first produced when they came into contact with the fibre. Even aniline black is no true black dye. Our description of it comes in the chapter on the black-dyeing of wood.

The most suitable real black dye for our purpose is Cassella's naphthol black. It is sold as a bluish-black powder, and gives a deep violet solution in boiling water. It fixes best on wood when applied very hot, and best of all with a little bisulphate of soda. To get a deep black it should be mixed with a little yellow. We recommend for this purpose naphthol yellow or fast yellow.

Another black dye suitable for wood-dyeing is jet black (Bayer). It is one of the newer basic dyes, which dyes wood without the use of acids or alkalies. The addition, however, of a little common salt is advisable.

The mark R gives bluish-black shades of great permanence in the air, while jet black G gives a strong dead black.

Finally, there is alizarine black, the fastest known black dye, which is also quite fast to acids. It is best fixed with dilute sulphuric acid.

The various benzidine blacks have no interest for us as they are not suited to our purposes.

As an appendix to the aniline dyes we give a short account of the anilines soluble in fat, and also of aniline lakes, which are largely used for dyeing marble and stone and for dyeing and varnishing wood.

Aniline Dyes Soluble in Fat.

Most aniline dyes are insoluble in neutral oils and fats. Methyl violet is an exception, and many processes enable us to prepare dyes soluble in fats. For example, most

anilines dissolve in organic liquids of high boiling point such as nitrobenzole, aniline oil, fusel oil and carbolic acid. For dyeing oils the dye is generally dissolved in aniline oil. Aniline oil dyes are largely made by precipitating the colour bases from the dye solutions with caustic soda and then combining them with warm oleic or stearic acid. The oleates and stearates so obtained have the colour of the base, and as they will dissolve in fats will dye them. Another method is to precipitate a solution of a basic dye with soap, which also gives compounds of the dye base with fatty acids. For example, if fuchsine, which is hydrochloride of rosaniline, is so treated with a soda soap, we get chloride of sodium and stearate of rosaniline.

Another method of dyeing fats is to dissolve the dye first in sulphoricinoleic acid neutralised with soda or ammonia so as to form the well-known sulpho soap. The soap used to dissolve the dye must be as nearly neutral as possible, as free acid or alkali in it might change the colour of the dye. Of course only fatty bodies can be dyed by any process which has no action on the dye which it is proposed to use. They must, for example, be free from lead.

A very different method for getting anilines soluble in fat, which he calls resinate colours, is due to Müller-Jacobs, and shall be briefly described. The discoverer had observed that the precipitates formed by metallic salts in solutions of rosin-soaps would combine with all basic aniline dyes to form distinct compounds. These coloured lakes have been introduced into commerce by the name of resinate colours. They are made as follows: 100 lb. of pale colophony, 10 lb. of dry caustic soda (96 per cent.) and 33 lb. of crystal soda are boiled with constant stirring in 100 gals. of water for an hour. The liquid is then brought down to about 50 deg. C. by the addition of 100 gals. of cold water. To this rosin soap solution is added a filtered

solution of a basic dye such as fuchsine, methyl violet, brilliant green, safranine, chrysoidine, auramine, methylene blue, rhodamine, etc., using, according to the colour wanted, from 5 to 10 lb. of the dye. If the temperature is too low, or the concentration of the soap solution too great, the operation will fail as the colour bases will be precipitated as abietates. To the solution of soap and dye is next added a dilute solution of a metallic salt, little by little, with constant stirring, till precipitation is complete. This point is known by dipping a strip of filter paper into the liquid. A slight excess of metallic salt facilitates the subsequent filtration and washing. For precipitation with zinc I use about 55 lb. of zinc sulphate for every 100 lb. colophony, previously dissolved in 100 gallons of water. It must be remarked that the mechanical properties of the precipitate depend largely on the quantity of water used. The precipitate is now filtered off, best in a filter-press, and thoroughly washed. The resulting hard cakes contain from 18 to 25 per cent. of resinate colour. Unless made from very dilute solutions the magnesium resinate lakes cake together instead of, like the others, being finely divided, and in their mechanical properties they are resinous. They must therefore be washed in filter bags, and dried at as high temperatures as possible.

The lakes, if not to be sold as paste, are dried at from 40 to 50 deg. C., but at 70 deg. for magnesium lakes, until they cease to lose weight.

These lakes when dry are extremely light, and in either lumps or soft powder, and have unusual freshness and beauty of colour. They electrify on rubbing more than colophony itself. Air and damp affect them in no way. They yield no quantity of their colouring matter worth mentioning either to cold or to warm water. Weak alkalies or acids have no action on them, and even strong solutions of hypochlorites only attack them exceedingly

slowly, provided they have not previously been exposed to light, in which case oxidising agents destroy them readily. In alcohol they are all more or less soluble, according to the metal used. Resinates of aluminium, beryllium, iron, nickel and manganese, whether coloured or not, are almost insoluble in spirit; while those of zinc, lead, cadmium and silver are fairly soluble; those of the alkaline earth metals still more so; and that of magnesium most of all. The dry lakes dissolve easily in their own weight of benzole and its homologues, of ether, chloroform, acetol and many essential oils. The solutions dry when painted on a flat surface to a hard, transparent, lustrous-coloured varnish which however, unfortunately, soon cracks and flakes off. The durability of the coat depends largely upon the metal present. The lakes are also readily soluble in alcohol, benzole and turpentine varnishes, in fused wax, in resins, in palmitic or stearic acid, in oleic acid and its homologues, in rancid fats and boiled oil. The solubility decreases as the amount of dye increases, and that amount must not exceed 20 lb. for every 100 lb. of colophony used in the manufacture. In oil of turpentine and the hydrocarbons of the mineral oil series ($C_{10}H_6$) the lakes are quite insoluble. Some of the metallic resinates, that of aluminium for example, quickly decompose in solution, even in the dark, precipitating the metallic oxide, while others, *e.g.*, of zinc, lead, calcium and magnesium, will keep unchanged indefinitely. Heated rather above 100 deg. C., the lakes fuse without decomposition, but break up at higher temperatures. In an open fire they burn, and, like colophony, with a smoky flame, leaving the metal as oxide. The resinate lakes stand light fairly well, much better indeed than the combinations of fatty acid with aniline bases dissolved in benzole. The worst lakes are made by brilliant green, no matter what the metal is. On the other hand methyl violet, safranine, chrysoidine, auramine

and rhodamine make good lakes whatever the metal. Rhodamine probably makes the best and most brilliant lakes of all. The aluminium and chromium lakes usually bleach more easily than those made with zinc or magnesium. By exposure to light, especially in thin coats, the colours lose their solubility in benzole completely, behaving exactly like a resin, asphalt in particular. We may infer that the light decomposes the lake into free dye and metallic resinate first, and that the latter is further changed subsequently. The dye set free can be completely extracted by any solvent that will act on it when it is by itself, or can be acted on by hypochlorites or other oxidising agents. If, for example, a piece of paper is painted over with a resinate varnish and exposed under a negative, a print can be made on it, as dilute alcohol or *eau de Javel* will afterwards dissolve the varnish where it has not been protected by the negative. The lakes which are soluble in alcohol exhibit this property much better than those which are insoluble, although the optical properties of the dye have a great influence on the result which is obtained.

As can be gathered from the above description of the properties of these bodies, they can be used for all sorts of purposes, whether dry or in the form of paste. In making transparent oil or benzine varnishes the resinate colour is either added to the boiled oil in the necessary quantity or first dissolved in benzole. This at once enhances the body of the varnish. I generally use for this purpose the resinate of zinc, iron, copper, or magnesium, containing not more than 8 to 12 lb. of dye per 100 lb. of colophony. By adding solution of india-rubber or gutta-percha the elasticity and durability of the varnish is materially increased. Such a composition of special value, which can be used alone or mixed with other varnishes, is made by dissolving 30 lb. of magnesium resinate lake in

80 lb. of benzole and 200 lb. chloroform, and then adding 150 lb. of a $1\frac{1}{2}$ per cent. solution of india-rubber in carbon bisulphide and benzole and clarified by heat. Such varnishes are excellent for decorating bright metallic surfaces, or wood, paper, leather, glass, etc. In many cases, *e.g.*, in painting on wood, the resinate lakes of iron, chromium, copper and manganese, combined with Bismarck brown, are to be preferred, on the one hand for economy, and also for the sake of greater fastness to light. Very pretty dark brown or black shades are obtained with suitable mixtures of fuchsine resinate, green or blue, chrysoidine or auramine, and these do well for printing and lithographic inks, and for boot blacking, etc. Besides, textiles can be dyed in one bath with single or mixed resinate lakes in dilute solution in benzole. Unfortunately this form of dyeing only gives delicate light shades, but for these it is already largely used for silk, satin and artificial flowers, where the dye must not rub off, both on a household and on a commercial scale. The lakes are also good for printing and dyeing india-rubber and india-rubber goods, celluloid, oilcloth and linoleum, and for colouring mineral whites.

In the form of paste they are excellent for making coloured pencils, and when thickened with tragacanth, albumen, dextrine or starch, for carpet printing. It should be mentioned that the lakes when acted on by the vapours of their solvents pass into a dissolved transparent state, in which they will adhere to any surface like a varnish.

Aniline Colour Lakes.

The methods of making lakes from coal-tar dyes are the same in their essential features as those already described, *i.e.*, they are precipitated mechanically or chemically, or in both ways at once, on to a white base. We shall here confine ourselves to short descriptions of the most important of them.

Red Lakes.—The darkest ones and those most like cochineal and carmine lakes are made by the action of tannate of fuchsine on starch and alum mixed with solution of soda. The whole of the colour is precipitated, and the lake will yield none of it to water.

By mixing paste Paris blue with this brilliant violet lakes are got, which, with oil as a vehicle, appear very beautiful and permanent. The other coal-tar reds have no interest for us, not even the alizarine lakes.

Violet Lakes are made like red lakes, but are hardly used, except those of methyl violet.

Blue Lakes.—The most beautiful aniline blue lake is decidedly that of alkali blue. A mixture of starch and chalk is digested in alum solution, and solution of alkali blue is then added till the desired intensity is attained. The alum precipitates the blue completely on the chalk and starch. Alkali blue will answer for green lakes but not perfectly. Lakes made with Lyons blue and its allies have no particular beauty, and are rarely used.

Yellow Lakes.—Few aniline yellows are used for lakes. The only one giving an intense colour is picric acid on alumina and zinc oxide. It occurs in commerce as an orange-yellow powder under the name of golden yellow. According to Gentele the colour is chiefly due to dinitrocresol. Of other aniline yellows such as Manchester yellow, dinitronaphthol, naphthylamine yellow, naphthol yellow and Martius yellow, only the last is really fit for making yellow lakes. The lake is sold usually as a lime salt, but occasionally as a soda salt, and is also sometimes precipitated with alum.

Green Lakes.—The most important green lake is that of methyl green. It is mixed with extract of quercitron or picric acid. The white basis is kaolin or alum, gypsum or sugar of lead. These quercitron lakes are very brilliant.

The quercitron may be replaced by a decoction of Persian berries.

Brown Lakes.—Under this collective name many aniline lakes are sold of very different composition. They are made from aniline brown, Bismarck brown, cinnamon brown, garnet, Havana brown, phenyl brown, vesuvin, alizarine brown, etc.

Black Lakes.—The only one we need consider is nigrosine lake, although for the same results it comes much dearer than logwood lake. Black lake made from aniline salt or oil is hardly ever used.

3. DYEING MARBLE AND ARTIFICIAL STONE.

VII.

DYEING MARBLE.

The art of dyeing marble has been well understood since the days of ancient Greece, for various statues of that period showing that they have been dyed are preserved.

The dyeing of marble is to-day very fashionable in Italy, and much money is thereby earned with little labour, for no particular qualification except some manual dexterity is required. We may be sure that we still use the same dyes employed by the ancient Greeks, adding, perhaps, cochineal and the dye-woods. On the scientific side, the dyeing and imitation of marble has made very little progress, and as in all purely empirical arts, where ancient recipes are jealously preserved secret, innovations are invariably kept at arm's length.

The result is that the work is usually done with very few colours, chiefly verdigris, gamboge, dragon's blood, cochineal, redwood and logwood. Greens are always made by mixing yellows and blues. Nevertheless nearly all vegetable dyes are suitable, and many of the coal-tar colours, if properly used, give very fast and beautiful colours to marble. For all dyes it is essential to use their solutions in alcohol or ether, and of anilines only those soluble in fat may be employed. If these rules are broken, the results will be bad. The preliminary treatment of the marble has also to be considered: in what weather the

dyeing is done, whether the dye solution is to be hot or cold, whether the marble has to be warmed before or after the application of the dye. The dye tinctures penetrate the deeper into the stone the warmer it is. The marble is usually warmed by heating an iron plate red-hot, and passing it over the place to be dyed until the marble is hot enough. In many cases the marble is heated after dyeing.

As in all dyeing, the intensity of the colour is regulated by the concentration of the dye solution. That is a different thing from saying that strong dye solutions penetrate more deeply. This depends on the nature of the dye alone. As a general rule, aqueous solutions penetrate the marble least, tinctures better, and solutions of the dye in wax best of all.

It is unnecessary to lay stress on the fact that only well-polished marble can be dyed. The quality of the marble is also of importance. It should be fine grained and neither too hard nor too soft. We must also remember that on marble, being a carbonate, acid dyes cannot possibly be used, for they will not only injure the marble but will themselves be totally changed. We shall consider the different colours in order, and we have already described the dyes and their methods of preparation.

Red.

Very warm reds can be produced with cochineal. The cochineal is put into strong warm spirit, closely stoppered, and allowed to stand for three or four days in a warm place. The solution can then be used. If too dark it is diluted with spirit, and is applied warm to the stone. The marble then assumes a beautiful and durable scarlet-red colour.

Equally permanent reds, but of somewhat different hue, can be got as below:—

Warm tincture of annatto gives a brilliant red.

A solution of dragon's blood in alcohol as hot as possible gives a lustrous red which can be made much faster by subsequently heating the marble, and which then also penetrates much more deeply.

A very fast dark red, which also penetrates very deeply, is given by nitrate of silver, but the colour blackens in time with many marbles.

Reds of somewhat bluish shade are got with hot tinctures of redwood. One of these, however, sandalwood, gives yellowish reds.

I wish to mention among anilines only fuchsine soluble in fat. Carefully mixed with hot wax it gives brilliant magenta shades, but too concentrated solutions cause much bronzing and the colour easily rubs off.

Violet.

Violets are chiefly got with tinctures of redwood alone, or mixed with logwood tincture. Alum alters the shade.

Warm tincture of alkanet or of mallow, too, gives beautiful violets, but of less fastness than the preceding.

A fairly fast purple violet can be got with chloride of gold, but the colour hardly penetrates the stone and is very expensive.

Among anilines I place methyl violet first, and next geranium violet. The first is used in oil or wax, the latter as a tincture, and both are applied warm. Methyl violet in hot wax penetrates deeper than geranium violet, but the latter colour has the advantage on the score of fastness.

Blue.

It is hardly practicable to colour marble blue. The assertion that it can be done with solution of copper sulphate is erroneous, and seems to have been made by some

theorist and afterwards accepted as gospel. I am unable that way to get any colour having any pretension to be called blue. Attempts with ammonium cuprate, too, were failures.

Blue anilines soluble in fat and tincture of Lyons blue certainly give a blue, but the colour does not suit the stone, and is only used when absolutely necessary. Solution of the aniline in wax penetrates deeper than the tincture of Lyons blue but is less fast to light.

Green.

This colour is produced with verdigris almost exclusively. Alcoholic verdigris solution gives a pale bright green, but a compound of verdigris and fused wax gives a fuller and an emerald green, which also penetrates the marble much better, reaching a depth of two-fifths of an inch, or twice as far as the alcoholic liquid.

The colour can be shaded with yellow by adding to the alcoholic verdigris a little tincture of gamboge.

Although there are aniline greens soluble in fat they have not yet been used for marble, as they give in no way the results which might have been expected.

Yellow.

For marble this is the colour most used and most sought after. Hence its production is the most advanced branch of marble-dyeing, several chemists having made improvements of which we will inform our readers without delay.

One of the most usual dyes is gamboge, carefully dissolved in spirit, and applied warm with a brush. The marble must be warmed after dyeing. A very beautiful dark yellow is produced by tincture of saffron. The stone simply requires painting with the warm solution.

Less usual is the employment of orpiment in spite of the

very fine results it produces. It is only necessary to brush over the marble with a solution of the pigment in ammonia. As the solvent evaporates, the beauty of the colour comes out. Orpiment is very poisonous.

We now come to the process of Dr. Weber of Berlin, which solved the problem of dyeing white marble durably with any shade of yellow, and uniformly, with a penetration of at least a twelfth of an inch, and without altering the nature of the marble.

This process is based on the little known fact that ferric salts are not precipitated from solution in strong alcohol by calcium carbonate, which does precipitate their aqueous solutions. Such alcoholic solutions also penetrate the marble better. The physical effect of the marble on the dye solution has also to be taken into consideration. When the strong tincture meets the surface of the marble where there is an angle we can observe in the resulting transparency of the stone how deep the alcohol penetrates. The soaked part has not the same shade as the solution as the alcohol penetrates further than the dye, leaving the latter near the surface. Dr. Weber observed that heat altered this effect by diminishing the absorptive power of the marble for the dissolved iron salt; for, while the dye penetrates less deeply into the cold marble, it does not merely remain on the surface when the marble is moderately heated but easily penetrates a twelfth of an inch and upwards. If the dry marble is subsequently wetted with water the iron salt inside the stone is decomposed by the carbonate of lime, and finely divided oxide of iron separates out in a state mechanically inseparable from the marble. The reaction can be watched by observing the change of colour.

The iron salt used is neutral ferric chloride. It is dissolved in 85 to 90 per cent. spirit and applied warm to the warm marble with a brush or by pouring. The concentra-

tion of the tincture to be used depends on the depth of colour wanted, and experience of the temperatures required is necessary. It is best to make repeated applications of a very dilute solution, especially for light shades.

When dyed and dried, the marble is wetted with water or exposed to damp air. When the decomposition of the iron salt has taken place the process is finished. The surface can then be polished, or if it was polished before it must be well rubbed with a wet cloth. The marble does not suffer in hardness or in power of taking a polish by the dyeing.

Many sorts of marble have an irregular texture, soft in one place and hard in another, and may contain enclosures of foreign matter. Even those which appear whitest and most uniform to the eye are not of the same texture throughout, and the variations often cause the artist much trouble. They naturally make the different parts of the stone behave differently to dyes. According to Weber this is particularly the case when considerable penetration has been produced by heating, and less when little colour is used and when the penetration is slight.

Marbles which, when dyed to some depth below the surface, show unlevel shades will, nevertheless, always take delicate shades uniformly if painted over with the tincture of iron when only slightly warmed. Although in this case the colour does not penetrate so deeply, repeated wetting and drying and polishing with a wet cloth will give a quite sufficient colouring to the stone. Even the most homogeneous marble should not be dyed till the sculptor has done with it.

If veined and naturally coloured marbles are treated hot by Weber's process specially mottled effects can be produced which are often very valuable, especially in close-grained stone.

The best concentration of the iron tincture depends on

the depth and nature of the shade required. Tinctures weak in iron give more yellowish shades, while those strong in iron give reddish hues. The shade can be graded by adding a little manganous chloride to the iron solution. If that salt is to be used, the marble when dry after dyeing should be treated with alcohol containing a little ammonia before being wetted with water. Experiments seem to have shown that this process is applicable to other dyes besides iron. It has also been found that when the marble is wetted with aqueous solutions of salts having no chemical action on it they have very varied degrees of penetration. Ferrous salts, for example, penetrate very slightly, but permanganate of potash colours slabs half an inch thick right through in twenty-four hours.

Few of the vast number of aniline yellows are used by us. Picric acid is less used than formerly, while auramine, in the form of a resinate lake, is finding increased employment. Its use, however, gives rather a harsh colour, and at a greater cost than Weber's process.

Orange.

These are usually produced with mixtures of red and yellow. Tincture of saffron gives a reddish-yellow, Weber's process as described above with the manganous chloride gives marble an orange hue. The colour, however, like brown, is in no great demand.

Brown.

For this tincture of cutch is used in various strengths. Only yellow cutch or gambier must be used, and for certain shades this is combined with annatto. Or the marble after dyeing with the gambier can be well rubbed with annatto in oil.

Anilines, *e.g.*, Bismarck brown, give unsatisfactory results as regards beauty and fastness, although many attempts have been made to use solution of the dye in spirit. The dyes soluble in fat answer better, but none can be compared to gambier.

Black.

Although marble is often dyed black, and oftener than people believe, especially when unsuccessful attempts have been made to dye it another colour, the recipes are still kept secret. Nevertheless, tincture of nigrosine, or better still, nigrosine and wax, will, according to its concentration, give every possible shade up to the deepest and fullest black.

Production of Parti-Coloured Designs.

If various colours are to be applied to marble so as to produce a sharp design, sundry precautions have to be taken which we now proceed to relate.

Too many colours must not be put side by side, two or three at most, or they will not look well and will probably run. Again, it is not indifferent which colour is applied first. Those should go on first which want the most after-heating to make them penetrate.

If, for example, a red, yellow and green pattern is wanted, the yellow is applied to the marble first, then the dragon's blood, and finally the wax and verdigris. All colours used with wax must be put on last, and with great care, as they readily spread as soon as the stone is warmed. For all colours applied with oil of turpentine or spirit, the stone must be first heated. With tinctures of dragon's blood or gamboge the stone is not heated till after dyeing. This is done by passing a red-hot iron repeatedly close to the stone. This is a better plan than holding the stone over glowing coal.

The only point remaining to be mentioned is that the marble to be dyed must be carved, cleaned and polished, for it is obvious that no work can be done on it with chisel or file after it has been dyed.

VIII.

DYEING ARTIFICIAL STONE.

The processes for dyeing artificial stone are analogous to those employed for marble, but are easier of execution, and the more porous the stone the deeper the colour will sink into it. The same dyes are used as for marble, but water-soluble anilines will here give beautiful and fast effects.

Generally, however, artificial stones are dyed during their manufacture. The same is the case with the so-called gypsum marble, etc. This manufacture does not come strictly within our province, but as the dyeing is bound up in it we must discuss its chief features.

For a red, a combination of gypsum and cinnabar is exclusively employed. It is a good plan to make three mixtures containing different proportions of cinnabar, by using which any hue from light to dark may be produced. The shade may be intensified and yet made vaguer by mixing in soot. Soot can be so used with all colours to advantage.

For yellow orpiment and gypsum in various proportions are generally used. A little cinnabar can also be added to give variety of shade.

For green I have used chrome with the best results, obtaining much better effects than with the usual complicated mixtures of orpiment, light ochres and chrome yellow, with indigo or artificial ultramarine. They cer-

tainly give greens suitable for many purposes, but not a pure, fine colour. Guignet's green gives very good results.

For blue I have used only ultramarine and gypsum, which give a very beautiful and bright result.

Special effects can be got by adding to the coloured gypsum various shining bodies, such as filings of brass, tin or copper, little bits of eggshell, etc.

Moulding, polishing, etc., do not come within the scope of this book.

4. DYEING AND IMITATION OF BONE, HORN AND IVORY.

IX.

BLEACHING AND DYEING BONE.

Bleaching Bone.

Bone can be bleached by processes to be described under horn and ivory. The bone should first, however, be boiled for from two to four hours in water containing salt and soda, to free it from particles of flesh, marrow and sinew. On removal from the pan the bone is wiped clean with cloths, and rinsed in water.

For bleaching we may use sulphurous acid, bisulphite of soda, chloride of lime or peroxide of hydrogen or sodium.

Hedinger gives the following method: The bones are steeped for ten hours in turpentine in tightly closed iron drums. They are then removed, and boiled in water for three hours with a little soft soap, skimming frequently. At the end of the operation cold water is added, and the bones are taken out and allowed to dry on pine shelves, but without exposure to the sun. In a few days they will be quite white.

Another method is to do the boiling with dilute caustic potash and then to dry on shelves as above.

Bones intended for keyboards can be bleached by simply leaving them for ten or twelve weeks in running water. To get the highest possible degree of whiteness they can be treated with sulphurous acid afterwards.

If the bones are freed from fat by slow boiling, they will bleach quicker in running water, but exposure to the sun and treatment with sulphurous acid are still quicker.

Schmeisser recommends that sulphurous acid should never be used in the gaseous state, as it fills the bones with cracks. This effect is still more pronounced with ivory.

To bleach with chloride of lime prepare a solution of fresh bleach in four times its weight of water, and leave the bones or ivory in it for a few days; then rinse and allow to dry.

Angenstein's process consists in boiling bones or ivory in a concentrated solution of alum for an hour, and then brushing them thoroughly. They are then put into damp sawdust to prevent cracking.

Bones can also be bleached with a mixture of unslaked lime, bran and water. In this they are boiled till white.

Bleaching with urine and lime should be discarded, as, when worked afterwards, the bones make a lot of dust, full of ammonia and lime, which is very injurious to the health.

Another method is steeping in hot oil of turpentine for ten to twelve hours, then boiling in soap-boilers' lye, and finally exposing the bones to the sun. This gives a very good white.

Even very yellow bone or ivory is rapidly and perfectly bleached by peroxide of hydrogen. The bone or ivory is first dipped into benzine, then rubbed with a woollen cloth, and then placed in the peroxide till quite white.

When bones are wanted very white, it is important to begin with them as fresh as possible. The bleaching is then much more effectual.

Dyeing Bone.

The dyeing of bones, like their bleaching, is much like that of ivory. The same dyes with few variations are used for both, and also for horn. Here we shall describe the new processes for bone, but for ivory the older ones, which, although more troublesome, are much more certain. For horn special recipes are given which have stood the test of much experience.

The dyeing can be done direct with most dyes, but it is best to soak the bones for a long time first in very dilute nitric and tartaric acids mixed, so that some of the phosphate of lime is removed from them. The mordant used is tin-salt or stannous sulphate (made by acting on 4 lb. of tin with a mixture of 6 lb. of hydrochloric acid, 3 lb. of sulphuric acid and 6 lb. of water). For many colours the preliminary treatment with nitric acid must be omitted or the colours will be destroyed.

Black.

The usual process is to employ logwood decoction or a solution of the extract in one of the two following ways:—

(1) *With Bichromate.*—The bones are first treated for ten hours in a 10 per cent. solution of bichromate of potash or soda, and then put straight into a hot solution of logwood extract. The purer and more concentrated this is, the fuller and deeper the black will be. Fustic should only be used sparingly. The shade got is apt to turn somewhat green.

(2) *With Pyrolignite of Iron.*—This does not give such a fine black as bichromate, but one faster to light. After staying for five or seven hours in hot logwood the bones are taken out when the liquid has cooled and put at once into a 10 deg. B. solution of the pyrolignite. This black

can be shaded by adding acetate of alumina or alum, which makes the black brighter and gives it a violet cast, to the logwood bath. Fustic, on the other hand, deadens the black.

Bones are most easily dyed black with anilines, especially with the spirit-soluble nigrosines. No mordanting whatever is required. A fairly concentrated solution of the nigrosine is made in methylated spirit and the bones are soaked in it as long as necessary.

Many water-soluble anilines can also be used with advantage, such as jet black, wool black, Biebrich patent black, naphthol black and many others. The process consists in giving the bones a preliminary bath of strong acetic acid for a few hours and then steeping them in the hot dye.

Black dye may be formed in the bone by means of aniline hydrochloride. Dr. Godeffroy of Vienna recommends this process, and gives the following recipe:—

Soak the bones for one hour in a solution of 20 oz. of the hydrochloride and 2 oz. copper chloride in 300 oz. of water, and then transfer to 10 per cent. bichromate till a deep black.

A still better process than this somewhat troublesome one is to soak the bones first in a solution of—

Hydrochloride of aniline	20 oz.
Sulphate of copper	6 ,,
Common salt	8 ,,
Water	150 ,,

and to transfer them thence to a solution of pyrolignite of iron. Both processes give full blacks, fast to light, alkalies and acids.

The same advantages can be secured even more simply in a single bath without heat and in less than an hour and a half. The bones are simply placed in the following solution till finished:—

Hydrochloride of aniline	20 oz.
Bichromate of soda	10 ,,
Sulphate of copper	15 ,,
Sal-ammoniac	8 ,,
Sulphuric acid	5 ,,
Water	200 ,,

The black can be given a reddish cast by subsequent treatment with soap, and a greenish one by the action of strong acetic acid.

Red.

A beautiful red is got by treating bones first mordanted with nitric acid in a decoction of cochineal or a solution of carmine in ammonia. With the cochineal, alum and a little tartar are added to the bath. Deep red is produced by a solution of 30 oz. carmine and 10 oz. crystal soda in 50 oz. of water, made slightly acid with acetic acid. In this the bones are boiled to shade. More about this coal-tar dyeing, however, will be found under ivory-dyeing.

At present bones are almost solely dyed red with the coal-tar dyes, of which we have a large number at our service. The bones are first mordanted, usually with tin-salt, and then dyed with a basic dye, or are dyed direct in a single acid bath with an acid dye. The spirit-soluble anilines are the most easily fixed.

Among them we may mention fuchsine, extra ponceau, cardinal, amaranth, cerise, ruby S, eosine, rose Bengal, coralline, safranine and scarlet. For dissolving the spirit-soluble dyes they are heated with the spirit in a still with an upward condenser, or better in a strong closed vessel of copper or enamelled iron. The dyes require from ten to 100 times their weight of alcohol (90-95 per cent.).

Bluish-reds are best got with fuchsine, ruby S, cerise, cardinal and amaranth, all of which are soluble in spirit,

and any shade can be got by suitable concentration of the dye.

For delicate pink shades, eosine, rose Bengal and safranine are specially suitable. Scarlets are got without difficulty with extra ponceau, scarlet and coralline. Bones may be dyed direct or after mordanting with tin-salt.

Of the water-soluble acid reds I may mention brilliant croceine, ponceau R, pyritine RRO, scarlet, etc. All these require previous mordanting of the bones with tin-salt or hydrochloric acid.

According to the experience I have gained from many experiments the dilute acid alone is a sufficient mordant not only for reds but for other acid anilines. It is a decidedly cheaper mordant than citric or tartaric acid. Nitric acid is to be avoided entirely for reds as it impairs their brilliancy. After a sufficient time in the acid, the bones are transferred to the dye solution at about 50 deg. C. The acid dyes give more or less scarlet-reds, partly brick and partly crab reds. In any case the acid reds will soon be the only mediums used to produce that colour in bone.

Yellow.

The best mordant in this case is nitric acid, but dilute hydrochloric gives very good results.

The oldest and best known dyeing process is to soak the bones first in a hot solution of bichromate of potash and then in a similar one of lead acetate.

It is, however, much easier to dye bones with a tincture of picric acid, which gives a beautiful deep yellow which can easily be shaded at pleasure by mixing the tincture with tincture of safranine.

The use of turmeric, fustic, weld and saffron is now nearly obsolete.

Blue.

Until recently commercial indigo carmine and the extract were the only substances used for the blue-dyeing of bones. The use of ferrocyanide of potash was too troublesome, and never gave good results.

With commercial indigo carmine the process is extremely simple. The bones are soaked in a strong solution of it in hot water. Many of the spirit-soluble anilines can be used just as easily, *e.g.*, methylene blue, navy blue, fast blue, peacock blue, and benzyl blue, and also *bleu lumière.*

In dyeing with indigo carmine mordanting with acid is indispensable, but with the spirit-soluble anilines it is at the option of the dyer. Indigo extract and carmine give characteristic blues, but the anilines usually give much brighter and warmer shades.

Violets are easily got with suitable mixtures of red and blue anilines. A common but not very warm violet is got by mordanting with tin-salt and then dyeing the bones in a hot logwood bath. All the spirit-soluble aniline violets give brilliant hues just as easily, especially Hofmann's violet, ruby violet, Gentiana violet and Regina violet.

Greens are usually dyed with mixtures of blues and yellows in various proportions according to the shade wanted.

Ordinary green is got by first dyeing the bone with indigo carmine or an aniline, and then in a bath of fustic, quercitron, picric acid or weld. Here again, however, we have numerous spirit-soluble anilines, which give much warmer greens, especially malachite, ethyl, methyl and iodine greens. The bones are mordanted in dilute hydrochloric acid, rinsed, and dyed in the dye tincture. Malachite green is undoubtedly the best.

Grays and browns are now produced exclusively with anilines.

Permanganate of potash although lately strongly recommended, is strictly to be avoided, as the colour obtained although beautiful enough at first is very loose, especially in the lighter shades. Acid fumes in the air at once destroy it, and the least contact of the bones with dilute vinegar will make it disappear like magic.

To obtain a fine gray I specially recommend the use of spirit-soluble nigrosine. This unquestionably gives the best results.

A pretty and very fast brown can be dyed quite easily and conveniently with spirit-soluble Bismarck brown. The following dyes also give good browns, though with various reddish and yellowish casts: resorcin brown, Philadelphia brown, Berlin brown, mode brown. With the last three the colour can be shaded by adding a little bichromate to the bath.

X.

HORN.

Bleaching and Whitening.

Real bleaching of horn, which is always more or less darkly coloured, is impracticable without injuring the horn, as many experts have shown. We therefore content ourselves with whitening it.

To dye horn white it is first stained brown with red-lead and then dipped in hydrochloric acid free from arsenic and iron. This converts the lead sulphide into chloride which remains as a white precipitate on the horn and gives it a milky white opalescent appearance. The horn must not stay too long in the lead stain, which is

made by stirring up 5 lb. of caustic lime and 3 lb. of red-lead with caustic potash lye, or it will become brittle. It must not stay too long in the acid either, or some of the lead chloride will be dissolved out and the whitening partly undone. If care is taken satisfactory results are certain. If the horn is exceptionally pale at first the solutions should be used weaker.

Dyeing Horn Black.

By Wagner's Process.—As is well known comb-makers dye pale or speckled horn to make an imitation of buffalo horn. This is done with the red-lead stain already described. The combs are left entirely immersed in it for twelve to twenty-four hours, taken out, washed with water (usually mixed with a little vinegar), dried and polished. They thus acquire a fine black colour.

The theory of the process is simple. Horn contains sulphur, which forms calcium sulphide with the caustic lime. This sulphide dissolves and re-acts in the pores of the horn with the lead which has also penetrated in the form of calcium plumbate, and forms black lead sulphide. Hence the horn is dyed black to some depth below the surface. This method is very cheap and usually gives good results. It has, however, the great drawback that the lime often causes the finer teeth of the comb to lose their parallelism. The whole comb may be twisted if thin. There is yet another and greater disadvantage, *viz.*, that if damp gets to the combs dyed in this way while they are in stock, a few months sees them covered with a white crust which can only be removed with difficulty by polishing, and always returns again. This makes the combs unsightly and unsaleable. The cause is the formation of white sulphate of lead, and the harm is particularly likely to occur while exported combs are on the sea.

Dr. Wagner gives the following account of his attempts to devise a process free from these drawbacks. Logwood or galls are not to be recommended as they are difficult to use cold, and heat spoils the horn. Logwood and bichromate give a good black at a temperature that the comb will stand, but the black is not fast to even dilute alkalies. It was therefore necessary to find a mineral stain free from the disadvantages of the red-lead mixture. The only ones which were found not to oxidise in damp air were the sulphides of bismuth, mercury and silver. Sulphide of silver is barred by economic considerations. Bismuth was tried in many ways with the most discouraging results.

Mercury oxide made into a paste with slaked lime and water does not blacken horn, probably because no soluble mercury compound is formed, so that the mercury does not come into contact with the sulphur in the horn. Dr. Wagner, however, supplanted it by soaking the horn first in a solution of a mercury salt and then in one of potassium sulphide. He found that the nitrate was the mercury salt which gave the best results, and best of all in the form of Millon's re-agent for albumen.

To prepare the mercury solution dissolve 2 oz. of mercury in 5 oz. of cold concentrated nitric acid, and then dilute with 50 oz. of water. In this solution leave the combs over night, then rinse them quite free from acid. They are now red, and very much like tortoise-shell. They are next placed for one hour, or two hours at most, in a dilute solution of potassium sulphide. The blackened combs are rinsed first with vinegar, then with pure water, dried and polished. They have then, according to experts, the exact appearance of buffalo horn. Care must be taken in the polish as although the colour is very fast it does not go in very far.

Numerous experts have shown that very small quantities of the mercury solution suffice for the reddening, so that the process is to be preferred even on the score of expense.

There are still various other methods for blackening horn, which we will describe briefly.

Boil the horn in—

Domingo logwood	30 oz.
Acetate of alumina	3 ,,
Water	220 ,,

for half an hour, dry well, and steep in a 10 per cent. solution of nitrate of copper.

According to Andés a very fine black is got by boiling the horn in concentrated solution of sugar of lead. The blackening takes place from a reaction between the lead and the sulphur of the horn, forming black lead sulphide. The horn is boiled for from a half to one and a half hours, and carefully rinsed with vinegar and water. A deeper black is got if the horn is mordanted first with sulphide of potassium.

Several experiments in dyeing horn with hydrochloride of aniline and bichromate gave very good results, but the dye does not penetrate sufficiently.

Aniline Black in the Cold.—Mix together the following two solutions:—

1.	Aniline oil	12 oz.
	Hydrochloric acid (19 deg. B.)	14 ,,
	Water	25 ,,
2.	Bichromate of potash	18 oz.
	Sulphuric acid	20 ,,
	Water	35 ,,

Steep the horn in the mixture for from an hour to an hour and a half, then soak in a strong soap bath, dry and polish. Equally good results are got by the following, another cold process.

Fast Aniline Black.—Mix together the following solutions:—

1.	Aniline hydrochloride	15 oz.
	,, oil	3 ,,
	Water	30 ,,
2.	Bichromate of potash	20 oz.
	Concentrated sulphuric acid	20 ,,
	Nitrate of iron (45 deg. B.)	5 ,,
	Water	35 ,,

Steep the horn in the mixture for from an hour to an hour and a half, wash, dry and polish.

Gray.

This colour is got by analogous methods to black, merely using diluter baths. All the above directions for black dyeing will then give good results.

A beautiful gray is obtained by first dyeing the horn white and then staining it in ferric chloride solution to shade. If the chloride solution is strong the gray will be yellowish, but bluish if it is dilute.

Brown.

To produce browns, blues, greens, violets and reds the horn must first be dyed white, and then dyed by simple immersion in the tincture of the proper aniline dye. For brown the best dyes are Bismarck brown and resorcin brown.

Blue.

For this use Lyons blue or navy blue. It economises dye to mordant the whitened horn in a strong alum bath before dyeing it, and in this case a solution of indigo carmine answers perfectly, and gives a characteristic blue with a greenish shade.

Green.

This is best got by combining blues and yellows, for example, the tinctures of picric acid and indigo carmine or of malachite green. The whitened horn is simply placed in a mixture of the concentrated tinctures.

Violets are now dyed with methyl violet almost exclusively. The tincture of this dye certainly gives the brightest and most beautiful colours, which shimmer splendidly on the horn.

Mixtures of blue and red give results which are far from being successful.

Red.

We wish, before giving any practical recipes, to describe two processes: that of Burnig of Stuttgart, and that of Lindner of Berlin.

French Method of giving Horn a Beautiful Red Colour.—The usual stain by which the comb-makers make horn look like tortoise-shell is a mixture of soda, quicklime and white-lead, which causes brown specks on acting for fifteen or twenty minutes. Longer exposure to the stain makes the specks dirty-looking and spoils the effect. The French imitations are noted for their fiery red marks, which make them look very well, especially by transmitted light. On this ground Lindner had requests from many quarters to make a red stain for horn. Close study of the nature of horn and comparison of it with wool soon showed that the brown specks consisted of sulphide of lead in a finely divided state. Lindner determined to decompose the brown matter in the horn and convert it into oxide of lead by adding caustic soda to the red dye-baths. He had found by his own experiments, as empirical experience had previously shown, that they were of no use on the horn with the

brown marks, even after treatment with various metallic oxides. On adding caustic soda, however, he succeeded completely and obtained the very finest red colours both with redwood and with orchil. Perhaps, too, the caustic soda has the additional advantage of dissolving the fat out of horn.

Lindner's method, which is now universally used in Berlin, is as follows:—

The horn is first prepared in a mixture of nitric acid with three times its weight of water at a temperature of 30 to 37 deg. C. It is then mordanted with the usual mixture of freshly burnt lime with its own weight of white-lead, and twice its weight of soda. This second operation lasts ten to fifteen minutes, so that the specks only appear yellowish-brown. The horn is then rinsed and wiped, and brought into a bath of caustic soda lye of 20 deg. B. mixed with four times its weight of redwood decoction. The horn is finally rinsed, pressed, and after thirteen or sixteen hours polished. The decoction can be made by boiling Pernambuco wood with three times its weight of water. If zinc oxide is used in the mordant together with the white-lead, bluer shades are got. Tin-salts make the red more like a scarlet.

Tortoise-shell Imitation with Fuchsine.—The French are the best imitators of tortoise-shell, and distinguish themselves above other makers by the fiery red marks they produce. All the various processes used for this production depend on combining the sulphur of the horn with oxides or salts of lead. Burnig of Stuttgart has published a method he has discovered for getting this red marking. It has this distinct difference from its predecessors that it is independent of the sulphur in the horn, and fixes a pure dye on the material. He places the horn in solution of caustic potash, where it remains from five to sixty minutes, according to the strength of the lye and the nature of the

horn. The horn will then combine with fuchsine without further preparation. The dye is then applied to the parts to be marked in a thick paste, so that it will not run, but without any thickening. As soon as the fuchsine has dried enough at ordinary temperatures to show its usual bronzy appearance, it is removed with a wooden spatula, the dry paste is softened with spirit and again applied. It is impossible to prevent the colour spreading somewhat, but the parts which should not be dyed can afterwards be whitened again mechanically by polishing with soft soap or tripoli. The parts covered with fuchsine have a dark red colour which looks particularly fine by transmitted light, and are quite as warm in hue as in the Parisian-made horn. Exceptionally light horn alone makes them appear somewhat too blue. They stand both light and damp, an important advantage for this method, in addition to the ease and certainty with which it can be carried out.

Horn can be dyed with anilines in the ways already described for other colours. If water-soluble anilines are used the horn requires a preliminary treatment with caustic soda or potash lye, or with strong soap solution. Spirit-soluble anilines, however, require no mordanting.

Yellow.

These can be got with aniline yellow after mordanting with caustic soda lye, or just as well by immersing whitened horn in about a $1\frac{1}{2}$ per cent. solution of bichromate of potash until the desired shade is produced, which may be from a sulphur to a deep yellow.

We now proceed to the methods of giving horn a metallic appearance. The horn is prepared as usual without giving any colour. The application of chloride of zinc, by immersion or brushing, gives a yellow bronze colour, zinc chromate a green, chloride of copper a black, copper chromate

a brown bronze. Potash reddens all these bronzes. The bronzed articles are dried at about 68 deg. C., or in the open air in fine summer weather. When dry they are rubbed with a composition which gives them a beautiful appearance, and is made by heating together 16 oz. of tin amalgam (made by heating 5 oz. of quicksilver with 11 oz. of tin), 3 oz. of sulphur and 5 oz. of sal-ammoniac, all in fine powder till the quicksilver has evaporated, leaving a yellow mass.

Horn Buttons.

We finally quote from the *Industrie Zeitung* an account of the manufacture and dyeing of horn buttons.

For black-dyeing it is best to use nitrate of mercury and potassium sulphide.

Dissolve 13 oz. of mercury in 13 oz. of cold concentrated nitric acid and dilute with about 100 oz. of water, and leave the horn in the solution over night. Then wash it, first with water, then with dilute vinegar, and then with water again. The button-shapes are now cut out by machinery. The rim produced by the stamping is removed by children. Each button is then smoothed at the edges, and polished by means of a brush with a composition of which the main ingredient is wax. The buttons are then wrapped in paper by girls.

The waste horn from button manufacture is either used as manure or by heating and moulding is made into buttons of an inferior and less durable kind.

We shall here also briefly describe the process of Leopold Müller of Berlin for dyeing stone-nut buttons.

The nut or vegetable ivory as it is often called is the fruit of a palmaceous shrub which grows in the equatorial part of South America. Of late the plant has been regularly cultivated. The fruit, like that of a horse-chestnut,

has a rough spiny outer skin, which is removed before the nut is exported. Under it is the solid shell containing normally two, but sometimes more kernels, sometimes, too, only one. The chief shipping ports are Cartagena and Maracaibo. On breaking the shell the kernel, which is the part used, is seen, of the appearance and size of a potato. It is so hard that only steel tools will cut it. It contains under a thin brown surface layer a white compact mass closely resembling ivory.

Even fifteen years ago the value of this nut, which was used for ballast, was unrecognised, but since it has been used for making buttons there has been a great demand for it. The kernels are sawn by a circular saw into pieces of the proper size, which are then turned in a lathe.

The buttons are dyed before being polished, just as they come from the lathe. To certain dyes they behave peculiarly, and they will stand no acid. They differ very widely from the textile fibres in their affinities for dyes, and require specially prepared baths as they cannot be mordanted. That process would prevent the subsequent polishing.

Müller reports as follows on vegetable ivory dyeing: No exact recipes can be given for the dyeing of vegetable ivory buttons, as they are only dyed to order, and not for the purpose of being kept in stock. Again, the ivory shows, according to the place and time of year at which it was gathered, such varieties of structure and affinity for dye that no precise rules can be given. Nearly every parcel requires different treatment. Beautiful shades of all colours can be got by very gradual addition of dye to the bath, steady boiling, and keeping the bath always clear and bright. The buttons must always be perfectly clean and free from all fat. When they are in this state a short boil in a weak soap bath greatly increases the richness of the colour. Yellowish buttons are sorted out

from the rest, and reserved for dyeing black or at least dark shades.

Red is usually dyed with anilines alone. The buttons are put with water into a small pan, and the dye is dissolved separately in boiling water and put slowly through a filter into the pan with the buttons a little at a time. The bath is kept boiling all the time, stirring up the buttons with a stick till the proper shade is reached. The buttons are then taken out and allowed to dry on a sieve. They are then polished and bored.

A fine magenta is got with diamond magenta, a cherry red with cerise, and other reds with the corresponding anilines.

Yellow, especially straw yellow, is dyed with picric acid. A dark yellow is got by simply putting the buttons into a warm solution of bichromate. It has to be borne in mind that the colour deepens afterwards, so that the buttons must be dyed somewhat lighter than sample.

Green is dyed with malachite green. The powdered dye is dissolved in luke-warm water, and the solution gradually added to the buttons immersed in water. In the meantime the water is gradually heated, but not above 50 deg. C., and the colour is shaded during the progress of the dyeing by adding picric acid. If, however, quite a pale green is wanted, the picric acid is used first by itself. Green can also be dyed cold without any mordant with malachite green. The process only takes longer. Dark and Russian greens are got with a blue dye and picric acid.

Violet is dyed with reddish or bluish water-soluble methyl violet, used like fuchsine. Fine lilacs and mode grays are also dyed with it, of course using the dye in very small quantities.

Blue can be dyed either with aniline blue or alkali blue. The buttons are put into a soap bath aud boiled, after adding concentrated solution of the dye, for at least two

hours, then rinsed slightly and put into cold, weak acetic acid to develop the colour. If alkali blue is used some borax should be put into the soap bath. For blue-dyeing only the whitest buttons should be chosen so as to get pure shades.

Brown is got either with aniline brown, which may be shaded if required with fuchsine, methyl violet, malachite green, orange, etc., or with cutch. This being cheaper is more commonly used. After cutch-dyeing treatment with a hot bath of ferrous sulphate, bichromate of potash or bluestone is needed, according to the shade wanted.

Orange is dyed with anilines only, fixed like fuchsine.

Gray can be got capitally with sumach, boiling for a longer or shorter time according to shade, and then fixing with hot solution of green vitriol. A bluish gray is got by using galls in exactly the same way.

Water-soluble nigrosine gives a fine blue-black.

Black is dyed with logwood and bichromate. The buttons are boiled for at least half an hour in a strong logwood bath, and are then entered into a cold bichromate bath for ten minutes. They are then rinsed, and the whole process is repeated until the desired colour is obtained. Aniline black obtained with aniline salt or oil in the usual way never answers well.

XI.

IVORY.

New ivory need not be bleached, as it can be bought white enough, but old ivory which has become yellow with age is bleached exactly as described for bones. Ivory articles must be polished before dyeing, and the various methods of doing this must be acquired by practical experience. The dyeing of ivory is exactly analogous to that

of bone, and any deficiency in the following account may be supplemented by referring back to that of bone-dyeing.

I wish to mention here specially that the colourist cannot fail to be amused, when he peruses the literature of the subject, to find that the dyes stated as being requisite for ivory-dyeing are all vegetable colouring matters, knowing as he does that the finest and purest shades are got with spirit-soluble anilines. Hardly an author mentions these, but weld, fustic, redwood, logwood, turmeric and cochineal are always quoted as *the* dyes employed. We follow here the same order as for bones, and begin with black.

Black on Ivory.

The most expensive black, which, however, according to my experience, is not utilised in practice, is that obtained with nitrate of silver. There is no objection, nevertheless, to the process except its expense. I quote now one of the latest recipes for the black-dyeing of ivory.

Boil 20 lb. of logwood extract wrapped in a linen bag in 20 gallons of water for two hours. This will dissolve the colouring matter, and the insoluble residue in the bag is then removed. Then put in 2 lb. of calcined soda, and boil and stir till it is dissolved, removing all scum with a ladle. The ivory is stained in the liquid for two or three hours, and is then put into a bath of bichromate dissolved in fifteen times its weight of water.

Another recipe is to boil 20 lb. of crushed galls and 80 lb. of powdered verdigris in 60 gallons of water. Then filter, and boil up the clear solution with the ivory. Later the ivory is transferred to a bath of—

Logwood extract	20 lb.
Ferric acetate	10 ,,
Gum-arabic	2 ,,
Water	24 gals.

This bath is first boiled for an hour, and filtered.

The very full black, which may be shaded with aniline yellow, can be got on ivory with spirit-soluble nigrosine. If the ivory is first mordanted for two or three hours in very dilute acetic acid the black is deeper and more velvety.

Another black answering every requirement is got by steeping in a cold solution of aniline oil, water, hydrochloric acid, bichromate and blue vitriol, until the ivory has assumed the proper colour.

RED.

Here the chief part is played by cochineal. Various anilines are also used but mostly give less satisfactory colours. Prechtl gives the following antiquated recipe: Mordant for a few minutes in very diluted tin-salt solution, and then place in a decoction of Brazil wood. The red is much better if a little cochineal is added to this. The addition of fustic makes the red more of a scarlet. If the ivory is treated with weak carbonate of potash after dyeing it becomes a cherry red.

We quote another process from a New York technical paper. Scarlet cloth-cuttings are boiled in water, adding carbonate of potash little by little till all the colour is extracted. The decoction is then cleared with a little alum and filtered through linen. The ivory, previously mordanted with aqua-fortis, is placed in the filtrate till the desired shade is reached. The aqua-fortis must not be too strong nor may the ivory stay in it too long. The moment the least roughening appears the ivory must be transferred to the dye solution. This should be luke-warm, but not hot. A little practice will enable the dyer to get any desired shade. If part of the ivory is to be left undyed, it is protected by a coating of wax or paraffin. In this way any writing or design can be executed. The same use of wax or paraffin can, of course, be made with any dye. The method given by the New York paper is really good, and

gives excellent results if the cloth used has been dyed with cochineal, which is now rarely the case.

Andés recommends the following: Boil finely powdered cochineal in thirteen times its weight of water for three hours, and paint the ivory several times with the solution. When dry apply a mordant of tin-salt and tartaric acid. The result is a rich red. If the cochineal is boiled in a decoction of quercitron (one of bark to sixteen of water) instead of in plain water, all shades can be made, from yellowish to scarlet-red. The same author recommends for a permanent red on ivory Pernambuco wood in combination with tin-salt. It can hardly be supposed, however, that now when so many splendid aniline reds are at hand any one would use redwood, as the colour can be got with the anilines just as fast and far more easily. I can mention as very suitable the tinctures of fuchsine, extra ponceau, Russian red, cardinal, amaranth, camellia, cerise, rubine S, acid fuchsine, garnet S, the rubine, phosphine and methyl eosine, erythrosine, safranine, rose Bengal, phloxine and coccinin. These colours are equally soluble in water.

The ivory must be cleaned and bleached if necessary, and then steeped in the tincture, or the latter can be applied with a brush. If the solution of the dye in water is used, the ivory must be first mordanted with dilute nitric acid. While the dyeing is very easy with a tincture, the other method is difficult, for experience is requisite to judge the right strength for the nitric acid mordant. Instead of nitric acid, hydrochloric, acetic or tartaric acid is much used, and which to use must be decided according to which aniline dye is to follow. As water-soluble anilines which give rich reds we may mention fast red, orchil red, ponceau, scarlet GR, azorubine, Victoria scarlet, brilliant scarlet, Bordeaux, etc.

For dissolving the dye-stuff soft water must be used at the boil, and in such quantities as to make from $\frac{1}{2}$ to $\frac{1}{3}$ per

cent. solutions. Stir till solution is complete. If rubine solution has to be kept for some time, it must be preserved by the addition of spirit or part of the dye will precipitate. To dissolve one of the above-mentioned spirit-dyes in water make the bath alkaline first with a little soda, and filter before use. Ponceau, croceine and Bordeaux dissolve easily in eighty times their weight of water. There are so very many aniline reds that they enable us to produce every conceivable shade in the easiest possible manner. In spite of this we must not omit to mention that we can shade our reds at pleasure with aniline yellows and violets; in the first case towards orange, and in the second towards lilac.

Yellow.

Yellows are got with anilines on ivory exactly like reds. The most commonly used dye is certainly picric acid in spirit or water, spirit solution giving the best results. The solution should be filtered before use as a precaution. Of other yellow anilines soluble in water or spirit we may mention phosphine, aurantia, curcumine, Philadelphia yellow, Martius yellow, chrysophenine, brilliant yellow, chrysoidine, auramine, mandarin, methyl orange and metanil yellow. Special and very pure greenish-yellows can be got with quinoline yellow, which, however, is only soluble in spirit.

To return to the old processes, we will first again quote Prechtl. The ivory is first mordanted for a few minutes in dilute sulphate of tin. It goes straight from this to warm decoction of fustic, or of fustic and redwood for orange. Another process is to boil the ivory first in alum, and then to steep it for half an hour in an aqueous infusion of turmeric. Another beautiful yellow is got by using the turmeric in the form of tincture.

Andés describes the following method of producing a

chrome yellow direct on the ivory: Steep the ivory for a few hours in a 5 per cent. solution of bichromate of potash. Then transfer to a solution of sugar of lead in five times its weight of distilled water till done. By altering the proportions, or by adding a little lime, all sorts of shades can be got up to the deepest orange.

Blue.

The favourite blue was formerly indigo carmine only, the ivory being first mordanted with hydrochloric acid. Or the ivory was left overnight in an acetate of alumina solution of 4 deg. B., and dyed next day with indigo carmine. These were at one time the only known processes worth having, for the American process with verdigris only gives greenish-blue or rather bluish-green shades. It consists in first dyeing the ivory articles green in a solution of verdigris in dilute nitric acid, and then converting the green into blue with a strong solution of carbonate of potash or soda. Naturally these colours, and also those obtained with soluble indigo, will bear no comparison with those got with the aniline blues.

The following dyes soluble in water and spirit have to be mentioned: methylene blue, navy blue, peacock blue and benzyl blue. Of those soluble in spirit only the most important for us are Humboldt blue, aniline blue, king's blue and Gentiana blue. Less valuable, and soluble only in water, are: water blue, capri blue, brilliant blue, alkali blue, China bluc, black blue and many others, including the blue benzidines, none of which give specially good results in ivory-dyeing. Many experiments have shown that decidedly the most fast and beautiful colours are got with the spirit-soluble aniline blues. Kayser recommends, in order to secure the greatest possible penetration of the dye, that the ivory should undergo a preliminary treatment with a dilute nitric acid, and should then be thoroughly

rinsed with plenty of water, and, after dyeing in the tincture, dried, and finally rubbed with soft flannel to get a fine polish. Used in this manner the above-named water-soluble aniline blues are also well fixed. With alkali blue, however, a subsequent short fixing with very dilute sulphuric acid is to be recommended to bring out the full beauty of the colour.

Violets.

Violets are rarely required alone, and are always then produced with tincture of methyl violet. Of this dye there are so many marks from the reddest to the bluest that it is hardly possible to be ever under the necessity of using any other. We may mention as a historical curiosity that alkanet used at one time to be used. The root was macerated in alcohol for a long time and the tincture was filtered, and the ivory steeped in or painted with it. The resulting colour is very beautiful but, unfortunately, very loose, especially if exposed to the sun.

Green.

Until the aniline dyes were discovered there was no direct green, and the colour was always got by combining blue and yellow. The only exception was the verdigris green already described. Ivory was generally dyed blue with indigo carmine, put for a few minutes in very dilute tin-salt, and then dyed to shade in hot decoction of turmeric or fustic.

The present aniline greens far surpass these greens in lustre and richness. Most of them dissolve in either water or alcohol. Of these we may mention iodine green, methyl green, ethyl green and malachite green. Guinea green and olive green are only water-soluble. I, however, recommend that only tinctures should here be used. If the colour is too bluish add a little tincture of picric acid.

With this any desired yellow cast can be given to the green.

Gray.

Most gray shades are got like blacks, using, of course, only very dilute solutions. Andés recommends the following gray mordant as giving a very fine and fast gray, but it looks rather too expensive: Dissolve pyrogallic acid in twenty times its weight of water and steep the ivory in the solution for about twenty minutes. Then dry well, and put into a solution of ferrous sulphate in twenty-five times its weight of water. The gray can be made lighter by using still weaker baths, and strengthened and made more bluish by using them more concentrated.

Instead of pyrogallic acid we can use logwood decoction, or better, solution of hemolin, and the green vitriol may be replaced by pyrolignite of iron of 7 deg. B. This gives a brighter and more bluish gray, but the shade may be varied at will by altering the strength of the baths. By adding fustic the grays can be shaded with green.

The gray anilines are, of course, much used, partly because the processes are so simple, and partly because the results are so brilliant. Only two spirit grays need be mentioned, *viz.*, nigrosine and aniline grays, although the water-soluble silver gray is to be recommended for a few special purposes.

Brown.

Browns are often required on ivory, whether all over or only on parts. Partial dyeing is best done with permanganate, which, however, must be used with certain special precautions. The articles must first be absolutely free from fat, which is best effected by treating them with ordinary or with petrol ether. It must be remembered that the use of either of these involves considerable danger of fire, and should never be carried out in the same room

with a naked flame. When free from fat the ivory is steeped for from five to fifteen minutes in hydrochloric acid diluted with twenty-five times its weight of water, then well rinsed and placed in a half per cent. solution of permanganate of potash. Care must be taken no undissolved permanganate is left in the bath. The salt dissolves very slowly, and the solution is so dark that undissolved particles are very apt to escape detection. They will cause unlevel and speckled dyeing. The solution must be used cold, and the time of exposure to it depends on the shade wanted, as a matter of course. As soon as the dyeing is over, rinse, dry and polish the ivory as usual. For special and redder browns the ivory, after being polished, should have a bath of grenadine or fuchsine (a 1 per cent. solution). According to the length of stay herein the brown will be more or less toned with red. In using permanganate it must not be forgotten that the browns it produces are highly sensitive to sulphurous acid in any form. Even a weak solution of sodium sulphite destroys them, and makes the article perfectly white.

Cutch is another brown ivory-dye, but is now hardly at all used.

Among anilines the following (soluble both in water and spirit) may be used: Bismarck brown, mode brown, Berlin brown; and also (water-soluble only) fast brown, acid brown and nacarat S.

Designs on Ivory.

If it is a question of making black or coloured designs on ivory, it is best done by etching. Rub 6 oz. tear mastic and 3 oz. asphalt separately to fine powder. Then fuse 6 oz. of wax, and put in the powders a little at a time, first the mastic and then the asphalt. When a homogeneous mixture has been got by stirring it is poured into lukewarm water, and, while cooling, shaped with the hand

into sticks or pellets. Mastic is rather dear and can be replaced by clear colophony, which answers nearly as well. In this case the best proportions are 12 oz. asphalt, 6 oz. colophony and 3 oz. wax.

This composition is painted over the ivory which is first warmed and must show a well-polished surface. All along the edge of the wax coating make a raised border of wax so as to make a little bath with a wax bottom, in which the design is drawn, laying bare the parts of the ivory to be etched. The wax bath is now filled with concentrated sulphuric acid, which may be slightly warmed first to hasten matters. The exposed parts of the ivory are blackened by the acid. If the design need not be very sharp, wax alone can be used without any asphalt, mastic or colophony. If instead of sulphuric acid we use a solution of nitrate of silver and afterwards expose the ivory to the sun we get a very durable black pattern, and with gold chloride a purple-red one. When the etching is finished rinse in water and remove the wax with turpentine.

To make white stripes on a coloured ground on billiard balls, the balls are wrapped in a waxed strip of cloth so as to protect the parts to be white from the dye, and then dyed. The strip may be fixed securely with thread. Should the white colour have run into white streaks, which it is very apt to do, the colour is removed by careful scraping. It must be mentioned that all colours are much faster on unpolished than on polished ivory, so the dyeing should be done before polishing. The polishing is done by rubbing with soap and Vienna chalk with the bare hand. In dyeing, the ivory must not be boiled too long, or it will crack. As soon as it is taken out it should be quickly cooled by being thrown into cold water. To silver ivory it should be put into a weak solution of nitrate of silver till it is a dark yellow and then exposed in water to the direct rays of the sun. After about three hours the ivory

will be quite black, and when dried and rubbed with a soft leather will assume a splendid silvery lustre.

Ivory shares with bone the property of being softened by dilute acids. This can be utilised to mould it. Soak the ivory for three or four days in a mixture of 2 oz. of nitric acid and 5 oz. of water. It will then be soft enough to be dented by the fingers. The softened ivory is then dyed if desired, and shaped by being pressed into metal moulds. When taken therefrom it is buried in very dry common salt, whereby it recovers its former hardness. Phosphoric acid can also be used for softening ivory, and is used in a solution of 1.13 sp. gr. Laid in this the ivory partially loses its opacity. When it is soft enough it is washed with cold water, and is then restored to its former hardness and opacity by steeping in hot water.

Batonnier and Michel of Paris have patented a process for fixing several colours at once on bone, ivory or horn, without allowing them to run into one another. Meal is made into a thin paste which is spread on a sheet of paper. On this again the colours are placed in the form of powder or thick paste, and the sheet is then applied to the surface to be dyed, naturally with the coated side next to it. To ensure perfect contact a metal plate is applied to the back of the paper, and the whole is placed in a suitable press. The whole arrangement is then brought into a steam chamber, or placed in boiling water. The colour then fixes on the surface of the ivory, etc. Finally, the paper is removed and the dyed surface is washed and dried in the shade.

Painting and inlaid work is imitated by C. Spatz (German patent No. 34) in the following manner: Transfers are laid upon a sheet of gelatine and more gelatine is then poured over them, so as to enclose them. The result will have a different appearance from either ivory or tortoiseshell.

5. WOOD-DYEING AND IMITATING FANCY WOODS.

XII.

DYEING AND STAINING WOOD.

THIS industry is not yet practised on a large scale in factories, except in very isolated cases. For a long time, unfortunately, the art had no secure foundations. To make the matter clearer I may mention that practical men do not speak of dyeing at all but of staining wood, however the colour may be produced. A distinction should be drawn between dyeing and staining in the common interests of all concerned, and we shall here restrict the term dyeing to the use of coloured dyes, and the term staining to the use of colourless liquids which cause the wood to assume particular colours, such as salts, acids, and alkalies.

The art of wood-dyeing consists of imparting colours to cheap home-grown woods which are not natural to them, without the application of pigments, and also of bringing out and beautifying the various veins and markings in the wood.

The commonest woods selected for dyeing are lime, pear-tree, walnut, acacia, elm, horse-chestnut, fir, pine, ash, maple, beech and plane.

The wood to be dyed must be first carefully planed and smoothed with a file, or with fishskin, pumice or glass paper, so that nothing has to be done after dyeing but to bring out certain parts. The deeper the dye penetrates the more durable the colour. Most of the shades produced

are very loose to light and require a protecting varnish to shield them from the effects of air, sun and damp. The varnishing, which will be more fully described later, has also the aim of increasing the beauty of the appearance of the work.

The art of varnish-making consists in dissolving by the aid of heat one or more resins in a liquid, so that the resins unite well with it and with one another. The solvent used must evaporate quickly after the varnish has been applied, and leave the resin behind as a transparent coat which must not crack or flake off. Few solvents fulfil all these requirements, and, in fact, there are only three sorts of varnish, pale or spirit varnishes, fat or oil varnishes, and turpentine varnishes. Most varnishes contain turpentine with the object of making the resin less brittle. The preparation of the varnish must vary according to the nature of the body to be varnished, such as wood, metal, gypsum, bone, etc.

We now return to dyeing. This is done sometimes warm, sometimes cold, according to the kind of wood, and to the desired intensity of colour. A cold dye never penetrates a given wood so deeply as a warm one, especially if the latter is applied more than once, or the wood is left a long time immersed in it. Each case must be treated individually in the following pages as no general rules are possible.

We now proceed to describe the latest dyeing processes, and shall pass afterwards to the more important special processes.

Black.

Although we have now countless methods for dyeing wood black proposed, yet the chrome logwood process is the only one adopted. The well-polished wood should be

rubbed with alum-water as a preliminary. Logwood always has to be used in combination with a metallic mordant, which may be iron, copper, chromium, vanadium or cerium.

Black with Logwood and Chrome.

The best and easiest black-dyeing process is with logwood decoction or a solution of the extract and bichromate of potash. The potash salt and the logwood are not mixed but applied alternately, and each coat is allowed to dry thoroughly before the next is put on. The first coat is usually of logwood. Chromate is sometimes substituted for bichromate but, in my opinion, with less success.

The alternate coats succeed one another till the desired shade is obtained. Hauboldt recommends a black dye which can be used without any mordant and will keep perfectly well. It is made by dissolving 40 lb. of logwood extract in 12 gallons of boiling water, filtering, and then adding 2 lb. of yellow chromate of potash first dissolved in water. It has a fine violet-blue colour, which soon becomes a deep black on wood.

Instead of this dye I would recommend as more suitable the well-known indigo substitute (hemolin, a logwood preparation). This dissolves in 1 per cent. acetic acid quickly and completely, and gives a brilliant blue-black to wood immediately.

Black with Logwood and Iron or Copper.

This is dyed as above with the exception that an iron or copper salt is substituted for the chromium compounds. The cheapest black is that with green vitriol, but that with nitrate of iron gives distinctly fuller and finer results. Copper-blacks, especially that with copper nitrate, have always a somewhat greenish hue. I will give a recipe, which although old, gives a black which is much superior to

those produced by the new processes. I possess articles dyed by means of it sixty years ago which have a most brilliant appearance. The wood is first mordanted in lukewarm solution of alum for half an hour, and logwood raspings having been boiled with water till the volume of the decoction is reduced by one-half, the colour is painted over the mordanted wood. A little indigo carmine with the logwood improves the colour.

The first coat gives a violet hue and is followed by two others, drying each time. The wood is finally, when dry after the last logwood coat, painted over with a solution of verdigris in hot vinegar. It is finally polished with an oiled brush. The appearance is improved by subsequent varnishing.

Ebony Blacks with Galls.

I here give another antiquated process which gives very excellent results, as is proved by articles dyed by it. The process may be varied by using commercial calcined sulphate of iron, or by substituting for the galls one quarter of their weight of tannin. I give here the original recipe in full as I received it.

Twenty-five oz. of coarsely crushed gall nuts are steeped in 100 oz. of water in a glazed vessel. In another 18 oz. of calcined sulphate of iron and 75 oz. of iron filings are digested for 24 hours in 25 oz. of strong vinegar.

The vitriol is calcined by placing it in powder on an iron plate kept nearly red hot, and letting it remain till it ceases to bubble up. The wood is first painted with the iron solution and, when dry, with the gall infusion, and so on alternately three or four times. One or two coats of soot and brandy are next put on. The wood when dry after this is polished with tripoli and a wet rag, and finally dried and polished with a dry cloth.

Black by Berger's Method.

A solution of vanadic and nitric acid is mixed with ammonia to a clear green solution. The application of this to wood first mordanted with a 2 per cent. solution of tannin gives a greenish-black. Vanadate of ammonia gives better results on the mordanted wood however. It is used as a 2 per cent. solution. To get deep full shades the tannin mordant must be applied several times. In many cases a solution of logwood extract can be advantageously substituted for the tannin.

Black with Pyrogallic Acid.

This black is rather too dear for ordinary use, but the black is very fine and velvety, and if such an one is required no better process can be used. It is to be noted that the pyrogallic acid must not be too weak, and that two or three applications of it must follow each painting over with iron salt. Pyroliguite of iron gives distinctly the best results, but ferrous sulphate will do.

Aniline Black by Godeffroy's Method.

The use of aniline oil or hydrochloride (aniline salt) in textile dyeing induced Dr. Godeffroy to try it for wood. He dissolves 100 oz. of the hydrochloride in 1,500 oz. of water, adds 2 oz. of copper chloride and paints the wood with the hot solution. When dry again it is painted over with a 5 per cent. solution of bichromate, and then when dry is of a beautiful black. The colour is fast to light and remains so. It never turns green, and neither acids nor chlorine affect it.

Paris Ebony "Stain".

Under this name a dye is put on the market made from the following recipe: 60 oz. of logwood extract solution

of 6 deg. B. are mixed with 20 oz. of solution of wax in concentrated carbonate of potash, and 20 oz. of the decanted solution from 9 oz. iron filings and 30 oz. of nitric acid. To this mixture add 2½ oz. of gum-arabic and the same weight of common glue. The stain is then ready for use, and is said to give excellent results.

It only remains now to speak of the coal-tar dyes, but we can refer the reader to our previous description of their action on wood. Only those soluble in water are used for that material, and they can be employed cheaply and effectively.

Gray.

Till very recently these were got with a stain and a dye combined, but now gray or black aniline dye solutions of suitable concentration are largely used. By varying the nature and the ingredients according to the wood all sorts of shades can be obtained. The following table gives the chief examples:—

Reddish pale gray, on maple	Chrome alum, 10 deg. B., or ferrous sulphate solution.
Mouse gray, on acacia	Bichromate solution.
Mouse gray, on apple	Solution of iron pyrolignite.
Mouse gray, on pear	Solution of iron pyrolignite.
Mouse gray, on birch	Chrome alum solution.
Dark medium gray, on oak	Copper nitrate solution.
Pearl gray, on oak	Chromic acid solution.
Pearl gray, on alder	Solution of ferrous sulphate.
Pearl gray, on cherry	Solution of ferrous sulphate.
Pearl gray, on lime	Acidulated solution of bichromate.
Pearl gray, on elm	Acidulated solution of bichromate.

Brighter grays are easily got with any basic gray or blue aniline. The first coat is applied warm, but always very dilute. After drying apply a 10 per cent. solution of tartar emetic, which will make the colour much faster.

Fine grays can, of course, be obtained with logwood and metallic mordants as for black, adding also, if desired, tannin and pyrogallic acid. Vegetable matters containing tannin can be used instead of tannin itself, for instance acorn-galls, gall nuts, sumach or divi-divi. All that has to be remembered is that dye and mordant must invariably be applied separately, drying after every coat. Only in this way can handsome fast colours be obtained.

I conclude with an old recipe for gray on wood: Dissolve 6 oz. alum and 25 oz. of ferrous sulphate in 100 oz. of boiling water. Stir in a little tincture of galls, and apply with a brush.

One of the most important colours for wood is a fine fast brown. We will begin with some recipes, which, if old, nevertheless give excellent results.

Brown.

Quicklime is slaked with urine, and the wood is painted over with the mixture. The wood is then washed with tanners' waste liquor. It then becomes green. Both processes are repeated till the colour changes to brown. The alkaline solution can be replaced by one of caustic soda, and the tanners' waste by a solution of tannin.

Another method is to mordant with alum and ferrous sulphate, and dye in logwood.

A third method is to boil dry green walnut-husks with alum, and paint wood with the decoction. Mouldy roots of the tree can be used instead of the husks. The husks, however, answer better, but they should be gathered in the autumn and left in heaps for at least two months to mould. They are then crushed and boiled with twice their weight of water and a little alum. This liquid gives a splendid and very cheap brown. The roots are stamped and boiled in the same way.

Brown with Bismarck Brown.

Dyeing with this and other basic anilines is perfectly simple, and consists simply in applying a warm solution in water. If it is desired to get fine clear shades it is very much better to apply a weak dye solution several times than to try to use a stronger dye with a single application. Let each coat dry before the next is laid on.

Brown with Permanganate.

Browns got on wood with permanganate of potash are of no special beauty, but they are very cheap and fairly fast. Here again it is essential not to work with too concentrated a solution. This, especially if hot, destroys the brushes, and will never give level colours.

The following table gives the browns got on the various woods with the dyes and stains indicated:—

Reddish pale brown on white beech	Nitric acid and 4 times its weight of water.
Reddish medium brown on white beech	Solution of carbonate of potash.
Reddish dark brown on white beech	Solution of chromic acid.
Yellowish pale brown on elm	Nitric acid and 4 times its weight of water.
Yellowish pale brown on pine	Nitric acid and 4 times its weight of water.
Yellowish pale brown on maple	Nitric acid and 4 times its weight of water.
Dark brown on maple	Solution of chromic acid.
Pale brown on maple	Solution of carbonate of potash.
Full yellowish-brown on cherry	Solution of cutch and bichromate.
Full brown on cherry	Solution of potassium ferrocyanide and acetate of magnesia.
Full reddish-brown on ash	Solution of cutch and bichromate.
Medium brown on alder	Solution of chrome alum.

Medium brown on maple	Hydrochloric acid.
Medium brown on acacia	Solution of carbonate of potash.
Yellowish medium brown on apple	Solution of potassium ferrocyanide and acetate of magnesia.

In combination with alizarine red, yellow or brown, using a copper or chrome mordant, many browns can be got which have the advantage of being more or less fast to all external influences.

A remarkable mahogany dye is said by Schmidt to consist of aloes and hydrochloric acid. Mr. Schmidt, however, has evidently made a mistake; he must mean nitric acid, for the former acid gives no red fumes with aloes. If we boil aloes with six times its weight of nitric acid of 36 deg. B. red fumes are evolved, and when they have passed off, which soon happens, the dye is ready, and is applied to the wood after dilution with three times its weight of soft water. This dye has the advantage that the colour darkens after application and also the drawback that the nitric acid attacks the wood and prevents the subsequent polish from lasting.

If the acidity were the only fault of this dye it would be possible to avoid it by nearly neutralising, best with chalk.

According to the same author the following brown "stain" is used in imitating antique wood: 2 lb. of coffee substitute (from the residues of sugar manufacture), which has a shiny fracture, are boiled in from 6 to 8 lb. of water, and articles carved out of Indian walnut wood are painted with it, or with a mixture of soot and five times its weight of very dilute spirit. In this way a very ancient appearance is imparted to the carvings.

We now give some recipes due to Leo of Benstein, and given by him to the trades' unions of Hesse. They may be of interest and value to many of our readers.

Pale Walnut Dye.

Dissolve permanganate of potash in thirty times its weight of water, and paint the wood twice with the solution. After five minutes wash with water, dry, oil and polish. The solution should be fresh. Cost—2½d. per sq. yard.

Dark Walnut or Palisander.

The same solution is used, but after the washing the dark veins are brought out by painting with pyrolignite of iron. Dry, oil and polish as before. Same cost.

Dark Mahogany.

Digest 3 oz. chopped alkanet, 6 oz. powdered aloes and 6 oz. powdered dragon's blood for three or four days in 100 oz. of 95 per cent. spirit in a closed flask, in a warm place, shaking frequently. Mordant the wood with nitric acid, dry, and apply one or more coats of the tincture till the desired colour is attained. Then dry, oil and polish. This recipe is also suitable for floors.

Pale Mahogany.

As above, but applying one coat only. A skilled hand can imitate the veining of the genuine wood by means of a brush filled with pyrolignite of iron. This, too, is suitable for floors, and costs 2½d. per sq. yard.

These preparations can be bought ready-made mixed with oil.

VIOLET.

Violets are at the present day produced almost exclusively with coal-tar dyes. According to circumstances alizarine red or methyl violet is used, but the demand for violet-dyed wood is very small. We here give three old

recipes for violet-dyeing which can often be adopted on wood with the most excellent results.

Dissolve litmus in water and paint the wood with the filtered solution. If the colour comes out too dark give a second coat with a weaker solution. When the colour is right dry and polish.

Another process is to make a decoction of 15 oz. of redwood and 33 oz. of logwood adding 8 oz. of acetate of alumina.

A third process is to dye the wood red, dry it, and then paint with solution of indigo. Or the wood may be first dyed blue and then painted over with a red dye.

A full violet is prepared by mixing indigo substitute with carmine red (oxidised redwood extract) in various proportions. For example, 3 oz. indigo substitute and 2 oz. of the red in 50 oz. of water acidulated with 1 oz. of acetic acid give very beautiful violet shades, which can be made even more brilliant with 1 to 2 per cent. of methyl violet (on the combined weights of the carmine and indigo substitute).

Stubenrauch's Violet.

Paint the wood with, or immerse it in, a solution of 2 oz. tree oil and 2 oz. calcined soda in a pint of boiling water. When the wood is dry paint it over with solution of fuchsine, or better, with solution of methyl violet in twenty-five times its weight of spirit. Parma or Victoria violet will do as well. The shade may be varied at pleasure with tinctures of different strengths, and the colour is equalled in brilliancy by hardly any other wood-dye.

Dull Violets.

The lively and rich violets are not as a rule great favourites, especially for furniture. Finer and duller shades

can be got with alizarine or benzopurpurine. Alizarine red and acetate of alumina on pear give a dull reddish-violet, while the same dye with sulphate of copper gives a bluish shade on birch. Medium subdued violet on birch is got with benzopurpurine solution of 4 deg. B.

Blue.

Here as with violets the anilines are fast making the natural dyes obsolete. Water-soluble fast blue is largely used with a tannin mordant. Very brilliant staring pale blues are got with spirit-soluble water blue, Lyons blue, *bleu lumière* and light blue. These dyes, however, only answer for white wood and for special purposes.

Logwood extract is now hardly ever used for dyeing wood blue. The following recipe once much used is now practically abandoned.

Boil litmus with sixteen times its weight of lime-water for half an hour, and apply several coats of the solution to the wood.

Stubenrauch's Blue.

Mordant first with solution of acetate of alumina of 1 deg. B. This is prepared by mixing a solution of 2 oz. of lead acetate in fifteen times its weight of water with one of 8 oz. of iron-free alum in 40 oz. of water, and adding a pinch of soda crystals. When the mixture has cleared, decant from the precipitate of lead sulphate and dilute with water to 1 deg. B. The mordanted wood is then dyed a beautiful blue by a solution of indigo carmine, of strength proportionate to the shade desired.

Blue alizarines, although very fast to light, are difficult to use, and are hence rather neglected. Indigo substitute gives a reddish-blue.

Red.

Most reds, especially for furniture, are desired in dull subdued shades, but some are wanted bright and lively. In the second case the aniline-reds are mostly used as they alone will give really rich shades. For bright pale reds the wood must be first bleached. This is done with bleaching powder and a little soda, and the wood must be as pale as possible naturally. To remove the last traces of bleach from the whitened wood, rinse thoroughly several times, and then apply a solution of antichlor. Some old recipes which follow are to my knowledge still largely adopted.

Red on Wood.

First mordant for a few hours in a solution of alum in thirty times its weight of water. Then steep to shade in decoction of redwood. The colour can be made somewhat darker with a little saffron. If the decoction is made with vinegar instead of water, the red comes out much warmer, especially on soft wood. It makes the colour much faster if a little isinglass solution is added to the redwood decoction. In that case, however, the dye must be applied warm to warm wood.

Second Recipe.

Dissolve dragon's blood in vinegar or spirit, and paint on the mordanted wood till the colour is as wished.

Third Recipe.

This is a strange enough recipe, but is said to give very good results. The chief part in the process is played by hippuric acid.

Place a hamper full of horse-dung over a tub to receive the drippings from it. The moisture and the fermentation of the dung must be promoted by watering it with

horse-stale. The liquid collected will in one or two coats give a very durable colour to wood.

It has been discovered that this process does not answer equally well with all woods. The difference has been ascribed to differences in the porosity of the wood. It has also been asserted that it answers better on wood grown in damp places than that grown on heights and in very dry soils. The process dyes some woods purple-red and some pink-red. Veiny fir for example receives a marbled, wavy colouring. Old wood, too, assumes a different tint from freshly cut stuff, so that experience is necessary in using the method.

Red on Wood.

Take 12 oz. of coarse Pernambuco wood sawdust and cover completely in a wide-mouthed vessel with spirit. Warm gently for forty-eight hours, and filter the tincture. The residual sawdust is treated for another forty-eight hours with warm water. The two solutions are mixed and applied to the wood.

Deep Cochineal Red (Stubenrauch).

Boil 4 oz. of powdered cochineal in 32 oz. of water for three hours, and paint the wood with the decoction. When dry, give a coat of dilute tin-salt containing a little tartaric acid. The best proportions are 4 oz. of tin-salt and 2 oz. of tartaric acid in 64 oz. of water. If the cochineal is boiled in a decoction of quercitron bark in sixteen times its weight of water instead of in water, the use of the tin-salt enables all shades from yellow and orange to a deep scarlet-red to be produced.

Monier's Pink.

Place maple in a solution of iodide of potassium in twelve times its weight of water for a few hours and then

steep in a solution of sublimate of mercury in 40 times its weight of water. A very fine pink is the result.

We now come to modern red-dyeing, *i.e.*, to the use of aniline dyes. For light rich reds and pinks the various marks of brilliant croceine are decidedly our most useful colours.

Benzopurpurine, too, gives on white wood very good results, but not on all woods. For example, it gives a beautiful pink in alder, but on ash, cherry or elm it gives a brick-red. The following are some other examples of the effects of benzopurpurine:—

On pink a dirty reddish-brown.
On maple a dirty reddish-brown.
On lime a dirty reddish-brown.
On oak a dirty pink-brown.
On acacia a dirty reddish-brown.

The alizarines are also much used for dyeing wood, and have the advantage of being very fast to light. For light shades the wood should be first treated with a 7½ per cent. solution of Turkey red oil and then dyed with a 10 to 20 per cent. solution of alizarine red. The following table shows the effect of different mordants on the colour got with alizarine red:—

Acetate of alumina gives brownish-red.
Alum gives brownish-red.
Chrome salts and chrome alum give browner red.
Iron salts and iron alum give violet.
Tin-salt gives rich scarlet.
Nitrate of tin gives yellowish-brown.
Perchloride of tin gives yellowish-brown.
Bichromate and sulphuric acid give reddish-violet.

We must repeat here that aniline dyes must never be used too strong or the colour will never be clear and pure.

Yellow.

Here, as usual, we give the old recipes first.

Old Recipe with Turmeric.

The wood is first mordanted for a few hours in alum dissolved in thirty times its weight of water, and then painted over with turmeric decoction. When the shade is reached, the wood is placed for some hours in cold water and then dried. Fustic gives too dark and dirty a yellow. It is better to use tincture of turmeric than the decoction.

A solution of annatto in warm spirit also gives a beautiful yellow.

A Beautiful Yellow with Saffron.

Digest 3 oz. of fine-cut saffron in 25 oz. of 95 per cent. spirit for an hour with occasional shaking. Then add about 100 oz. more of the spirit, and heat the digesting vessel in warm water. With the tincture two coats are applied to the wood, and give it a very beautiful golden-yellow colour which can be deepened by further applications. When dry after dyeing, the wood is soaked in glue-water, again dried, and finally polished or varnished.

Yellow with Persian Berries.

These give a bright lively yellow. The berries are crushed and boiled for about half an hour in weak solution of alum. The solution is filtered, and painted on the wood. It may be kept for use in well-corked bottles, shaking well before application. This dye can be mixed with the saffron solution mentioned above for getting a deeper yellow.

Gamboge.

This should never be used for toys, for it is one of the most poisonous substances in its effects on the animal organism.

Chrome Yellow.

This can be produced cheaply and easily, by applying a solution of bichromate to the wood with a brush or sponge. Chrome compounds, however, must not be used on oak or walnut or other woods rich in tannin.

Yellow with Picric Acid.

A beautiful and very pure yellow is got with picric acid either in alcoholic or in aqueous solution. In either case it is simply applied warm with a brush. Other anilines are used in the same way, especially acid yellow, fast yellow and Victoria yellow.

Yellow Staining with Nitric Acid.

One of the cheapest and fastest yellows is obtained by the use of this acid, but it will not do for every kind of wood. We give some examples. The acid gives—

On white beech . . .	a reddish-yellow.
On elm	a pale medium yellow.
On pine	a brownish medium yellow.
On maple	a brownish medium yellow.
On acacia	a bright medium yellow.

Nitro-alizarine yellow, too, gives a yellow very fast to light. We now conclude with green.

Green.

Most greens are now produced exclusively with aniline dyes. We begin as usual with the older recipes.

Mixed Green.

It is well known that all shades of green can be got by mixing blues and yellows in various proportions. Very rich greens are got, for example, with indigo carmine and picric acid, but unfortunately they are rather loose to light.

Green with Acetate of Copper.

A very pleasing but poisonous green is got on wood by fixing a solution of verdigris in acetic acid with a sharp alkaline lye. Dissolve separately, each in 70 oz. of hot water, 25 oz. of sulphate of copper, and 30 oz. of sugar of lead. Then mix and filter, or decant the clear liquid after settling. The precipitate of lead sulphate is thrown away. The liquid is used as above directed.

Another Recipe.

Rub up powdered verdigris with strong vinegar, adding little by little green sulphate of iron. Then boil the whole in water for half an hour. Then paint the wood to shade with the solution.

Green with Anilines.

The following aniline greens are used without any mordant: iodine green, brilliant green, malachite green, acid green and Guinea green. The last, however, is often fixed with alum.

XIII.

IMITATION WOODS.

We have already described the production of special colours. We proceed now to describe more closely the processes for imitating various woods.

We must first consider the researches of Dr. Bergers, who was the first to describe the use of alizarine for the purpose, and to introduce it to practical use. We give his more important recipes.

The alizarine solution is made by diluting commercial alizarine red paste (20 per cent. of alizarine) with twenty times its weight of water, and gradually stirring in ammonia till the liquid smells strongly of it. This ammoniacal liquor costs about 3d. per quart.

1. Two applications of it on dried wood give—

With pine	yellowish-brown,
With maple	reddish-brown,
With oak	yellowish-brown,

at a cost of $1\frac{1}{2}$d. per sq. yard.

2. Dissolve crystallised chloride of barium in 100 times its weight of hot water, and use as a mordant before applying the alizarine. We then get—

On pine	a brown,
On oak	a brown,
On maple	a dark brown,

at a cost of $1\frac{3}{4}$d. per sq. yard. The mordant costs 1d. a gallon.

3. A mordant of chloride of calcium of the same strength as the barium solution costs the same, and gives with the alizarine—

On pine	a brown (like burnt Sienna),
On oak	a reddish-brown,
On maple	a dark brown,

at a cost of $1\frac{3}{4}$d. per sq. yard.

4. A mordant of 2 per cent. sulphate of magnesia costs 1d. a gallon, and gives—

On pine	dark brown,
On oak	dark brown,
On maple	dark violet-brown,

at a cost of $1\frac{3}{4}$d. per sq. yard.

These four recipes are specially good for imitating old oak.

5. A mordant of 3 per cent. solution of alum costs 1d. a gallon, and gives—

On pine	deep red,
On maple	deep red,
On elm	dark red,
On oak	blood red,

at a cost of $1\frac{3}{4}$d. per sq. yard.

A 2.6 per cent. solution of sulphate of alumina is better than the alum, and barely dearer.

6. A mordant of 3 per cent. solution of chrome alum costs 3d. per gallon, and gives—

On elm	reddish-brown,
On maple	reddish-brown,
On pine	reddish-violet,
On oak	Havana brown,

at a cost of $1\frac{3}{4}$d. per square yard.

7. A mordant of $2\frac{1}{2}$ per cent. solution of sulphate of manganese costs 9d. per gallon, and gives—

On pine	dark violet-brown,
On elm	dark violet-brown,
On maple	dark violet-brown,
On oak	dark walnut-brown,

at a cost of $2\frac{1}{2}$d. per sq. yard.

8. A mordant of 1.6 per cent. ferric chloride costs 1d. a gallon, and gives—

On elm	yellowish-black,
On oak	yellowish-black,
On pine	dark yellowish-brown,
On maple	a smoke brown,

at a cost of $1\frac{3}{4}$d. per sq. yard.

9. A mordant of 2 per cent. solution of crystals of green vitriol costs 1d. a gallon, and gives—

On pine	reddish-black,
On elm	reddish-black,
On maple	reddish-black,
On oak	black,

at a cost of 1¾d. per sq. yard.

10. A mordant of 2½ per cent. solution of crystallised cobalt sulphate costs 3s. per gallon, and gives—

On elm	dark brown,
On oak	dark walnut-brown,
On pine	lilac,
On maple	amethyst,

at a cost of 5d. per sq. yard.

11. A mordant of 2½ per cent. solution of crystallised nickel sulphate costs 10d. per gallon, and gives—

On pine	lilac,
On maple	lilac,
On oak	dark reddish-brown,
On elm	dark reddish-violet,

at a cost of 2½d. per sq. yard.

12. A mordant of 2½ per cent. solution of crystallised zinc sulphate costs 2½d. per gallon, and gives—

On pine	dark cherry-red,
On elm	dark cherry-red,
On maple	dark cherry-red,
On oak	dark reddish-brown,

at a cost of 2d. per sq. yard.

13. A mordant of 2½ per cent. solution of crystallised cadmium sulphate costs 2s. per gallon, and gives—

On pine	reddish coffee-brown,
On oak	coffee-brown,
On maple	reddish-coffee-brown,
On elm	coffee-brown,

at a cost of 4¼d. per sq. yard.

14. A mordant of 3½ per cent. solution of crystallised lead acetate costs 3½d. per gallon, and gives—

On pine	reddish-violet,
On elm	reddish-violet,
On maple	reddish-violet,
On oak	Bordeaux violet,

at a cost of 2d. per sq. yard.

15. A mordant of 2.9 per cent. solution of crystallised sublimate costs 9d. per gallon, and gives—

On pine	reddish-brown,
On maple	reddish-brown,
On elm	brown,
On oak	coffee-brown,

at a cost of 2½d. per sq. yard.

16. A mordant of 2 per cent. solution of copper sulphate costs 2d. per gallon, and gives—

On pine	reddish-violet,
On elm	reddish-violet,
On oak	brownish-violet,
On maple	cherry-red,

at a cost of 2d. per sq. yard.

17. A mordant of 2 per cent. solution of crystallised tin-salt and enough hydrochloric acid to make the liquid clear costs 3½d. per gallon, and gives—

On pine	the appearance of Pernambuco wood,
On elm	brown,
On oak	reddish-brown,
On maple	wine-red,

at a cost of 2d. per sq. yard.

18. A mordant of 2 per cent. solution of tartar emetic costs 4d. per gallon, and gives—

On pine	orange-red,
On maple	orange-red,
On oak	coffee-brown,
On elm	dark brown,

at a cost of 2¼d. per sq. yard.

19. A mordant of 1½ per cent. solution of nitrate of bismuth and enough nitric acid to make the liquid clear costs 1s. 6d. per gallon, and gives—

On pine	reddish-brown,
On elm	dark brown,
On oak	dark nut-brown,
On maple	dark cherry-red,

at a cost of 4d. per sq. yard.

The last three mordants require the application of ammonia to the wood after the alizarine or the free acid present will prevent the development of the colour.

The process with all these nineteen mordants is to apply the metallic salt with a brush, hot, and to let the wood dry before the alizarine is applied. If the colour is not strong enough both applications are repeated in the same order. If this is not observed, or the intermediate dryings are omitted, or the various solutions are used too strong, the colour will be streaky and wanting in uniformity.

Besides all these recipes Dr. Berger has tried ferrocyanide of potassium with many other metallic salts, and thereby got very successful results upon wood. Some of these are given below as examples, and show those which can be recommended for practical use.

1. A mordant of 6.8 per cent. solution of sulphate of manganese gives on pine, maple or oak a light drab.

2. A mordant of 6.5 per cent. solution of crystallised ferrous sulphate gives—

On pine	dark blue.
On oak	bluish-black.
On elm	indigo-blue.

3. A mordant of 6.5 per cent. solution of crystallised cobalt sulphate gives a light violet-brown on maple, pine or oak.

It will be of even greater interest to give the following table of the action of most mordants with the natural dyes. This table is taken from Andés, and is of the greatest importance for every wood-dyer.

Mordant.	Colour with			
	Logwood Decoction.	Fustic Decoction.	Redwood Extract.	Persian Berry Decoction.
Dilute hydrochloric acid.	reddish.	yellowish-brown.	pale red.	pink.
,, nitric acid.	red.	brown.	,, ,,	yellow.
,, sulphuric acid.	,,	brownish-red.	purple.	,,
Sulphuretted hydrogen.	yellowish-brown.	dark yellow.	pale red.	,,
Nitrate of iron.	black.	dark greyish-green.	dark violet.	dark olive green.
Bichromate of potash.	,,	,, ,,	brownish-red.	brownish-yellow.
Tin-salt.	violet.	yellow.	pale red.	dark yellow.
Tartaric acid.	grayish-brown.	,,	reddish-yellow.	white.
Sulphate of copper.	dark green.	orange.	dark red.	greenish-yellow.
Tannin.	yellowish-red.	light yellow.	red.	,, ,,
Sal-ammoniac.	yellow.	dark yellow.	dark red.	,, ,,
Verdigris.	dark brown.	,, ,,	,, ,,	,, ,,
Sugar of lead.	grayish-brown.	yellow.	yellowish-red.	dark yellow.
Ferrocyanide of potash.	yellowish-brown.	,,	,, ,,	pale
Permanganate of potash.	pale brown.	brownish-yellow.	dark carmine.	,, ,,
Carbonate of potash.	dark red.	yellow.	,, ,,	yellow.
Pyrogallic acid.	,, ,,	,,	,, ,,	,,
Ferrous sulphate.	black.	,,	dark violet.	pale yellow.
Alum.	dark red.	,,	,, red.	,, ,,
Sulphide of ammonia.	,, ,,	dark yellow.	,, ,,	,, ,,

The experiments are made by preparing a concentrated solution or decoction of the dye in water. This is painted on to slips of wood about 6 by 4 in., on both sides. When dry the slips are labelled. The mordants are prepared in solutions of three strengths, and painted over the slips, each of which has then the name and strength of the mordant used placed on the label where is already the name of the dye.

A patent which was taken out by a man named Thimm, and has now expired, protects a process in which wood was first painted over with solutions of metallic salts by means of a brush, dried completely, and then exposed in closed chambers to the action of gases such as ammonia, sulphuretted hydrogen, etc. In this way with the latter gas we get the following colours:—

With bismuth nitrate . . .	brown.
With cadmium sulphate . . .	yellow.
With tin chloride . .	golden yellow.
With lead acetate . . .	iron-brown.
With chromic acid	green.
With antimony salts	red.

The expense of the process is said to be very slight, but the principle is a wrong one, just as it is in textile-dyeing, and prevents all possibility of uniformity. For this reason Thimm's process was a failure.

It will also be of great interest to record how the different woods colour with the various dyes, and we give the following examples:—

Redwood decoction, prepared by boiling the wood for an hour with twenty times its weight of water, gave—

(*a*) With oak, plane and red beech . .	a ripe cherry colour.
(*b*) With maple, lime and white beech .	an old mahogany colour.
(*c*) With walnut wood	a red mahogany colour.

If these woods are soaked in a decoction of madder containing 20 per cent. of alizarine, they all take a uniform

chestnut-brown, which comes out best on plane and white beech.

Soaked with turmeric extract they become a pale yellow, which is very beautiful on plane and red beech, and best of all on maple which thus becomes like American satin-wood.

With aqueous solution of gamboge we get—

With poplar	a wax yellow.
With acacia	a lustrous dark lemon-yellow.
With walnut . .	a fine lustrous brown.
With pear	a fine lustrous brown.
With chestnut . .	an old mahogany colour.

Extract of saffron gives dark yellow on ash and chestnut, and a darker, more brownish-yellow on pear and walnut.

All the woods are polished before dyeing, and also dried for forty-eight hours at 40 deg. C. to open the pores and evaporate the sap. An old boiler is often used as a drying-chamber, and afterwards as a dyeing-vat in which the wood is soaked till the dye has penetrated about half an inch.

We now return to the imitations of various woods. These need only be spoken of briefly, for, as Hauboldt very justly says, it is not merely necessary to imitate colour and texture, but also weight and other physical properties. Hence it is futile to give processes for making fir or pine imitate a heavy wood as it is too light and has also a betraying texture which cannot be concealed. The chief requisite for the imitator is a skilful hand for using the brush, and the art cannot be learned from books, but by practice alone.

Mahogany Imitation.

The other wood properly chosen is well polished and stained with dilute nitric acid. It is finely varnished with properly tinted shellac varnish.

Dark Walnut Imitation.

For this a not too concentrated solution of permanganate of potash is the best.

Oak Imitation.

First apply an oil ground with pale ochre and a little white-lead. Apply two coats of this, the second only when the first is dry and has been polished with sand-paper. So far the process is the same in all cases, and in the following recipes it must be understood that this ground has been applied. Rub burnt sienna and Cassel brown fine with vinegar and apply with a brush, but not in too thin a state. Grain in the dark spots afterwards with Cassel brown, and then put in the veins with a proper broad flat brush, used by grainers for the purpose, with downward strokes. Another and stiffer brush used from below upwards serves for representing the pores of the oakwood. Naturally, the previous applications, *e.g.*, the veins, must have been allowed to dry or this process will smudge and destroy them. The medullary rays are then put in with the use of a stencil and a wet sponge, but not too wet, or the wet will get under the stencil plate. Oakwood knots are done with Cassel brown after applying the vinegar colour, and the year rings of the knots are put in with the sharply pointed side of a feather. The surroundings of the knots are done with a feather cut zig-zag, and tho pores and veins of the knot in the same way as those of the wood itself. To imitate nature thoroughly the characteristic wavy marks are imitated on the proper places, while they are still wet, with a brush 5 inches wide and with hairs at least 3½ inches long, dipped in vinegar, and finished and scumbled in the usual way.

Birch Bark Imitation.

The oil pigment ground is made several shades lighter than for oak imitation. The vinegar colour is burnt sienna, put on rather pale. Light-coloured parts are then put in with a damp sponge, and after the scumbling and other usual treatment of these the long pale marks are put in with a leather roller. The little knots are imitated by marks made with the tips of the fingers wetted with vinegar. For the dark ones Cassel brown is put on the finger-tips.

Alder Marquetry Imitation.

The oil ground is somewhat darker than for oak. A vinegar colour of unburnt sienna is first applied, and then, after grinding and sand-papering, a few red spots are put in with burnt sienna and darker ones with Cassel brown. The knots are done as above described.

Walnut Imitation.

The ground is still darker than it is for alder. The vinegar colour is Cassel brown, applied rather dark. The darker parts are now imitated with more brown, especially in the knots. The year rings of the knots are put in as described for oak, and the whole is scumbled in the usual way.

As soon as the colour is quite dry the wood is gone over lightly with Cassel brown, leaving out the dark spots, the characteristic year rings are put in, and the whole is scumbled once more.

Walnut Marquetry Imitation.

Here the oil ground must be still darker. The special grain is marked out with still darker Cassel brown, mixed

with a little black for the darkest places. The paler places are done first, and then the darker. Finally the whole is scumbled lightly but thoroughly.

Mahogany.

The oil ground is the same as for walnut marquetry. For ordinary mahogany we apply burnt sienna, using more colour for the darker places, and also a little Cassel brown. The pale places are worked in with a sponge. We then scumble and do the pores as for oak. For very dark wood (Spanish mahogany) the surface must be gone over again with more sienna, repeating all the operations.

Spanish Mahogany Imitation.

Paint on burnt sienna, putting in the places where the pyramids are to come somewhat darker. Then give the grain with a sponge and also the smooth places by the sides of the pyramids. The long streaks which occur in the pyramids themselves are done with a stiff card or leather. The whole is then scumbled and, when dry, gone over once more with burnt sienna. The veins which run over the pyramids are either done with the jagged edge of a card or with a proper brush, and the pores as usual. A final slight scumbling completes the work.

Palisander or Rosewood Imitation.

The oil ground is a mixture of English red and ochre, the vinegar colour is Cassel brown. This is applied thicker to imitate the dark places, and the darkest of all are done with black. Veins are put iu with the brush and the grain with a feather, as above described.

Tortoise-shell Imitation.

The oil ground for light tortoise-shell is chrome yellow, white-lead and pale ochre; that for dark tortoise-shell is

Prussian blue, ochre, white-lead and a little black; the vinegar colour is burnt sienna. With this the lighter places are first made on the oil ground and scumbled. When these are dry the streaks are put in with a stencil plate with more burnt sienna, not too wet. The places are then scumbled with the stencil still in place. Then allow to dry, replace the stencil, not quite in the same place, and go over the streaks so as to make them darker, and again scumble. Apply the Cassel brown a third time, but only here and there. When this is dry, varnish the wood, and let the varnish dry till it is only just sticky. Then let the smoke of a lamp come upon the dark places. Allow to dry completely and varnish again. The varnish to be used is good, quick-drying copal. When the varnish is quite dry polish with finely powdered bone earth, and finally with leather. The copal will then have a durable lustre equal to that of the best shellac.

Oak Imitation.

The articles, the wood of which is to imitate oak, are exposed to the fumes of ammonia in an air-tight chamber till finished.

Ebony Imitation.

For this we refer to our description of black-dyeing. The best woods for ebony imitation are pear, maple and white beech.

To Give the Appearance of Wavy Pearwood.

Make freshly burnt quicklime to a thin paste with dilute ammonia. Make the wavy marks with a brush full of this, wash them when dry, stain or dye at pleasure, and then varnish or polish the wood. Another way is to sprinkle

the wood with the lime paste, whereby it receives a fine speckled appearance.

Real Mahogany Imitation (without Oil Ground).

Make a very concentrated decoction of real mahogany sawdust and paint the white wood several times over with it. After drying and polishing it will have the lustre and colour of real mahogany.

XIV.

DYEING WHOLE BLOCKS OF WOOD WITH A PENETRATING DYE.

This is a very useful process, for in many branches of woodwork wood dyed through and through is required, and that which is bought is rarely sufficiently penetrated. The few processes so far known will be here exactly described, and one worked out by the author, which has given results which, for some wood-trades such as the walking-stick business, are extremely satisfactory.

The use of steam is essential to ensure the penetration of the colour, both during and after the black-dyeing, and full success depends upon that and upon the choice of a proper dye.

We will treat first of Andés' apparatus. This consists of a boiler and a dye-box, by means of which wood 1½ in. thick can be dyed through in twelve hours, and wood 2½ in. thick in fourteen hours, and so on in proportion. The wood is first thoroughly steamed in the dye-box till all its sap has been extracted and the condensed water runs bright and clear. The box is then exhausted with an air pump, and the hot dye solution is admitted. This is forced into the cells of the wood by the external atmospheric pressure and in time penetrates it completely.

Similar, but with a few variations, is the process of Gottheil and Auffermann of Berlin. They enclose the wood in air-tight cylinders, pump out the air from them, and then drive in the dye solution under a pressure of about thirty atmospheres. With ordinary thickness, from thirty to sixty minutes will finish the process, but very thick woods of course take longer.

A rather different method is that of Riefenbichler, which is said to give the very best results. The apparatus consists of a boiler and a cylinder to receive the wood, which, however, is heated by a worm so that the steam does not touch the wood. The boiler contains a stirrer capable of both rotatory and up-and-down motion so as to produce perfect reaction between the contents of the boiler. In working this cylinder is filled two-thirds full of the dye solution mixed with waterglass, the wood is introduced, and the cover closed air-tight. When the air has been driven out by the heat of the worm through a valve the external pressure begins to force the dye into the wood. What is further asserted with regard to the facilitation of the penetration of the dye to the interior of the wood by boring holes in it before treatment will hardly be taken seriously, even by people who are only very imperfectly acquainted with the subject.

Here, as well as in the above process, the black is got with logwood and a subsequent treatment with pyrolignite of iron. This method may be modified by reversing it and using the iron salt first.

Borton Jenks has investigated this dyeing system very thoroughly, and we append his chief results. He obtained—

Light warm grey with nitrate of iron.
Dark warm grey with nitrate of iron and paraffin.
Pale colder grey with ferrous sulphate.
Darker colder grey with ferrous sulphate and paraffin.

Pale or dark colder grey with various strengths logwood and green vitriol.
Dark warm grey with ferrous sulphate, logwood and paraffin.
Paler yellowish-grey with chromate of potash.
Dark yellowish-grey with bichromate of potash.
Fine yellowish-grey with bichromate of potash and paraffin.
Pale orange with logwood.
Dark orange with logwood and paraffin.
Slate blue with aniline blue.
Dark slate blue with aniline blue and paraffin.
Yellowish-violet with aniline red.
Dark yellowish-violet with aniline red and paraffin.
Purple with fuchsine.
Dark purple-red with fuchsine and paraffin.

The process is carried out by first steaming the wood, then making a vacuum in the steam chest and then admitting the dye, which is at once sucked up by the empty cells. The heightening of the shade is afterwards done with fused paraffin. The method has given admirable results on a large scale.

My own researches on the dyeing of large masses of wood were carried out for black through-dyeing in the apparatus as above described. The novelty which I introduced was the use of certain chemicals which make the wood still more ready to take up the dye through great thicknesses, but which will not injure the material or the wood, or alter the structure.

I have found the best reagent to use for this purpose to be a strongly alkaline solution of 75 per cent. soda Turkey-red oil. Although the beauty of the colour was not much improved, the penetration was made very much greater. The logs were first steamed without pressure and then dyed with a mixture of the Turkey-red salt and logwood decoction. The second treatment, with pyrolignite of iron, is preceded by another steaming. For some purposes the iron salt can be replaced by a solution of nitrate of copper

of 36 deg. B. This also gives a very beautiful black, and the choice between iron and copper is simply a matter of taste.

XV.

VARNISHES AND POLISHES.

Varnish is a name usually employed to denote any kind of application intended to produce a level and shining surface. They are commonly used for giving a brilliant appearance to pigments. For our purposes we sometimes use oil varnishes. These are made of vegetable oils, which dry naturally and are increased in their siccative properties by artificial treatment. This at the same time makes the varnish more brilliant. The non-fatty varnishes made with mastic, sandarach, benzole, copal and amber, and asphalt are, however, of more importance to us.

The art of making varnishes consists in dissolving the resins in suitable solvents and getting a perfect combination of all the ingredients. The solvents used must be such as will evaporate quickly after the varnish has left the brush, and the resin must be left as a transparent coat, elastic enough to keep whole and unbroken. We think we shall best meet the wishes of the reader by proceeding at once to give the best recipes.

English Polish.

The so-called English polish is of remarkable durability when made according to the English recipe and with good copal. That made in Germany is usually its equal in appearance, but far inferior to it in durability.

Take of—

Shellac	25 oz.
Copal	6 ,,
Dragon's blood	6 ,,
Very strong spirit	50 ,,

If light wood is to be polished the dragon's blood is omitted. It is a great improvement, however, for dark wood. The shellac and dragon's blood dissolve in the spirit without difficulty, but the copal requires a preliminary treatment before it will do so. This consists in mixing it in powder with three times its weight of finely powdered glass or chalk. It is then put by itself with half the 50 oz. of spirit in a flask on the sand-bath and kept warm. The flask should be frequently shaken. When the spirit has assumed a dark yellow colour and a few drops of it turn water milky it is decanted and replaced by the other half of the spirit. The second extract is, of course, weaker and paler. The two lots of spirit are finally mixed and used to dissolve the other ingredients with the aid of gentle heat. It is rare not to get perfect solution when this method is employed.

A polish thus prepared will endure considerable heat without losing its lustre, and lasts well on furniture in constant use. But if made wrongly, or with inferior copal, the results will be very different, and articles polished with it will soon lose their lustre in the sun or near a fire. At the same time it will get soft and collect dust, which will quite spoil its appearance and can only be removed by removing the polish itself.

This method of preparation has naturally the advantage over one consisting of a mere digestion of the resins with spirit. The surface of contact offered by the copal to the spirit is increased by the admixture of chalk or glass, and if the spirit is not quite strong enough, the chalk extracts part of its water. If the polish is to be made in large quantities a large green glass flask should be kept handy, and should be thin, so as to be less likely to crack. To avoid the same danger it should be gradually heated, and put on the sand-bath before the heating of the latter is begun. The flask can then be heated to boiling without risk. The sand used

must be sifted, as the presence of stones causes unequal heating, and probably the cracking of the glass. The flask must not be filled too full, but room for the expansion of the contents allowed, and so as to permit of the contents being shaken.

Experience has shown that soft wood wants thicker polish than hard wood. If too thick, the polish is diluted with spirit; if too thin, it is thickened with a solution of shellac in spirit. The addition of sandarach or mastic increases neither the lustre nor the durability. The polish must never be applied till the surface has been carefully smoothed by the usual processes, using last of all soft pumice steeped in oil. The oil is removed and the last finish given to the polish by means of a rubbing with brick-dust. The polish can then be laid on. This is done by soaking a pad of several folds of woollen cloth in the liquid and then enclosing it in a piece of calico first oiled with linseed oil. The whole is held in the hand by the corners of the calico and applied to the work with a circular movement till the whole surface has been done. Fresh oil must be put on the calico if it begins to stick to the wood, but the polish is only renewed when the first supply is exhausted. Before the pad is put away after use it must be well cleaned with spirit. When the proper lustre is produced the surface is dried and freed from oil by the light application of a cotton cloth. The oil is necessary to keep the pad in proper condition, but as too much of it interferes with the polishing it must be used with discretion.

Although the application of furniture polish may seem easy, it nevertheless requires great experience, and even very skilled workmen often have great difficulty with very soft wood. It is a good plan to give such wood a preliminary soaking in glue-water to stop up the pores. The polish must be applied, too, in considerable quantity after the glue is dry and the wood has been smoothed as above

directed. The first application of the polish is then made without reference to lustre, and is followed by a second polishing, first with pumice and water, and then with pumice powder and oil, and finally with the brick-dust. A second and slight application of the polish will then suffice to give the desired result.

Turned goods are polished in nearly the way we have described. The whole process is carried out on the lathe itself. After smoothing with fine glass paper, followed by the use of powdered pumice and oil on a woollen rag, the superfluous oil is removed with tripoli or burnt hartshorn, and the polish is applied with the pad. Small articles which would lose their sharp edges under the action of powdered pumice are smoothed with pieces of pumice-stone cut into the proper shapes. Care must be taken to move the pad to and fro horizontally, or the wood being heated by the friction will soften the polish, and so cause the pad to remove it again. This also hinders the proper action of the pad, as it clogs the rag and prevents the free exudation of the polish. While the pad is being rotated with one hand a finger of the other should be applied to the wood just opposite to it. The friction against the skin increases the lustre, and the feel tells the workman whether he is applying too much or too little pressure with the pad or rubber, and the removal of superfluous oil is facilitated. After the drying of the polish the last lustre is given with a new application of pumice and oil. In this way as good a lustre can be obtained as with any copal or amber varnish, although naturally the polish is not so durable as that given by those varnishes.

With regard to the means of preserving the lustre of a polished article and keeping it from injury, it must be remembered that it owes its beauty to the smoothness and closeness of its surface, whereby it reflects most of the light which falls upon it. These properties are produced by the

polish, which fills up all inequalities and presents a smooth compact exterior. Hence all liquids capable of acting on the polish must be kept away, such as spirits of all kinds. If such a liquid is spilt on a polished surface it dissolves some of the polish, and the water it contains precipitates the resins from the solution causing a whitish mark. Water alone does no harm, unless it is applied to the surface when the latter is warm through exposure to the sun or a fire. It is then liable to injure the lustre and cause a more or less opalescent or coloured appearance. The reason of this is that the heat opens the pores of the polish and enables them to admit the water. Hence the surface no longer reflects the rays of light uniformly. One must, therefore, be very careful when polished furniture is brought from a cold into a hot room not to wipe off water which condenses on it, but to allow it to evaporate. If polished wood has to be cleaned with a wet cloth it must never be rubbed or the heat developed by friction will open the pores and admit the water, and also make the surface apt to collect dust.

A simple solution of shellac is often passed off as English furniture-polish. It is simply made by making a solution of the shellac of the desired strength by warming with spirit. It is much less durable than the genuine article.

Amber Varnish.

Amber has long been used for varnish-making, but eighty years ago few possessed the recipe, and these charged very high prices for the varnish. The varnish must only be applied to a perfectly uniform and smooth surface. All cracks and small holes must be carefully stopped with a priming, and when that is perfectly dry the now uniform surface must be made quite smooth with pumice, etc. The best results are got by circular rubbing

with pumice, etc., in a dry and very finely powdered state. The surface is then wiped clean with a damp sponge and carefully dried with a soft cloth. If a very superfine smoothing is desired, a rubbing with starch powder may be given last before the application of the sponge. The wood is then gone over with glue-water, or with a body colour of white-lead and glue, and is then, when dry, ready for the varnish.

The best recipe for amber varnish is—

Amber	10 oz.
Pure oil of turpentine	15 ,,
Boiled oil	5 ,,

The coarsely powdered amber is wetted with some of the turpentine in a glazed vessel and left covered over for a few hours. The vessel is then moderately heated over a fire, and its contents are stirred with an iron spatula till thoroughly fused. It is then allowed to cool partially, and the rest of the turpentine, first made hot, is stirred in. The vessel is then returned to the fire, and allowed to froth up once or twice, when the linseed oil is slowly added boiling hot. The finished varnish is filtered while still warm through a plug of tow.

The wood, after smoothing and soaking in glue, receives two coats of the varnish, and thereby acquires a beautiful lustre. The varnish coat can, however, not be further polished. If the wood is light in colour varnish must be used for it made of the finest and palest amber, but for darker woods varnish made with the darker kinds of amber will do perfectly well.

Much depends on the purity of the ingredients of the varnish. The amber in particular must be cleaned from all dirt and impurities before solution as they cannot be thoroughly got rid of afterwards. It should be washed in lukewarm water, and dried in the sun in places free from dust and fumes, because amber absorbs them.

The amber may also be melted in a copper vessel. The clearness of the varnish usually depends on that of the linseed oil used, so that the oil must be carefully examined first. Linseed oil adulterated with rape oil is also to be avoided, as the varnish made with it dries much too slowly. If the opportunity presents itself of buying a really good oil, a large stock should be laid in, for the oil improves greatly by keeping, and old oil makes by far the best varnish. On keeping it deposits its mucilaginous and coloured particles, and becomes much paler and of far superior quality. The oil should be drawn off every year into a fresh vessel, and the sediment left behind in the old cask cleaned out and thrown away, or better, used mixed with lard for cart-grease, or for painting over coarse woodwork exposed to the weather. The gain in the quality of oil by keeping makes up for the loss of the weight of the sediment twice over. Boiled oil from freshly pressed raw oil is hardly ever clear, and amber varnish made with it is useless with light colours, as it darkens them and gives them a dirty yellow hue.

The boiled oil used in making amber varnish must be made from genuine crude oil. The oil may be purified to a large extent before boiling it by churning it with water for an hour. The water and oil are then allowed to separate, and the dirty water is run off. The whole process is repeated with more water as long as it is obvious that the water is removing dirt.

The boiling is done with litharge, sugar of lead, or white vitriol. Although raw oil is used for coarse work in the open, it is quite unsuitable for making amber varnish, partly because it dries so slowly and partly because it does not go so far.

Copal Oil Varnish.

Take of—

Coarsely powdered copal .	24 lb.
Pure oil of turpentine	26 ,,
Boiled oil	36 ,,

The copal is wetted with some of the turps in a glazed earthen vessel, and put over a fire to melt. As soon as fusion begins it is stirred with an iron rod till it is complete. Then the oil is put in boiling hot, a little at a time, and the fire is increased to make the varnish boil up once or twice. The vessel is then taken from the fire, and when it has cooled enough the rest of the oil of turpentine is stirred in. Then strain into a warm barrel. Before this varnish is applied, the wood is soaked with weak glue-water or with boiled oil, and when this priming is quite dry the varnish is put on with a brush. One coat is usually enough. If a second is necessary, it must not be applied till the first is dry. When the varnish is dry the surface is smoothed and polished.

Composition for Preserving Furniture.

Take small pieces of wax, white or yellow, and add to it as much oil of turpentine as will make a thick pasty solution. Rub the furniture with this and then polish with a woollen rag. This process will restore articles of walnut, marble or varnished metal to their pristine brilliancy. If it is to be used on red articles, the turpentine must be dyed deep violet with alkanet before the wax is mixed with it. The alkanet is simply soaked in the oil till the desired colour is produced. For mahogany this colour must not be too pronounced, because the wood itself browns with time. Cherry wood does not, however, so that the turpentine must be strongly dyed when used for making composition for this wood.

Only a small piece of the composition, about the size of a bean, should be used at a time, or very long rubbing is necessary. It is best to repeat the operations of rubbing with composition and with the woollen cloth, as a better lustre is then got. A final rubbing with a bit of old soft linen is to be recommended after the woollen rag has been used. The composition can be bought ready made.

THE END.

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